A CAHNERS PUBLICATION
INTERNATIONAL EDITION
JANUARY 4, 1990

EDN®

JAN 1990

Industrial PCs for harsh environments

Digital-storage scopes exceed 20 GHz

Designer's guide to flash-ADC testing

Graphics libraries for PCs

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Advances in switched-capacitor filter ICs shed light on new applications

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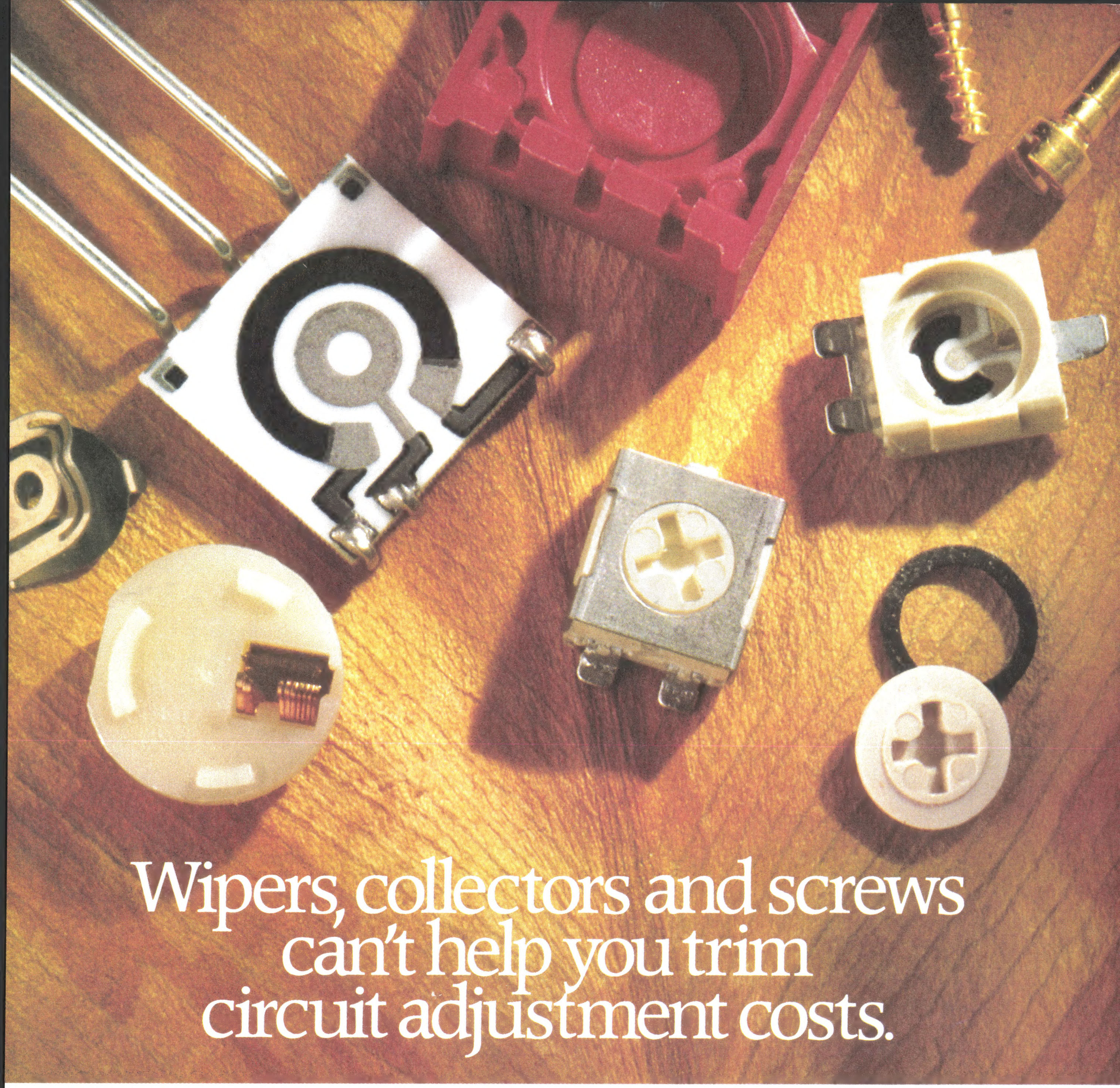

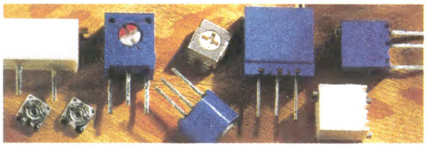

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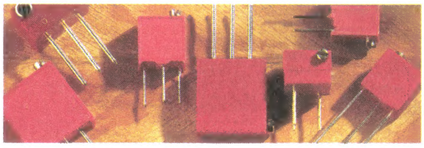

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Pin Model Connector Version	**KSW-2-46** **ZFSW-2-46**		**KSWA-2-46** **ZFSWA-2-46**	
FREQ. RANGE	dc-4.6 GHz		dc-4.6 GHz	
INSERT. LOSS (db)	typ	max	typ	max
dc-200MHz	0.9	1.1	0.8	1.1
200-1000MHz	1.0	1.3	0.9	1.3
1-4.6GHz	1.3	1.7	1.5	2.6
ISOLATION (dB)	typ	min	typ	min
dc-200MHz	60	50	60	50
200-1000MHz	45	40	50	40
1-4.6GHz	30	23	30	25
VSWR (typ) ON	1.3:1		1.3	
OFF	—		1.4	
SW. SPEED (nsec) rise or fall time	2(typ)		3(typ)	
MAX RF INPUT (bBm)				
up to 500MHz	+17		+17	
above 500MHz	+27		+27	
CONTROL VOLT.	-8V on, OV off		-8V on, OV off	
OPER/STOR TEMP.	-55° to +125°C		-55° to +125°C	
PRICE (10-24)	**$32.95** **$69.95**		**$48.95** **$79.95**	

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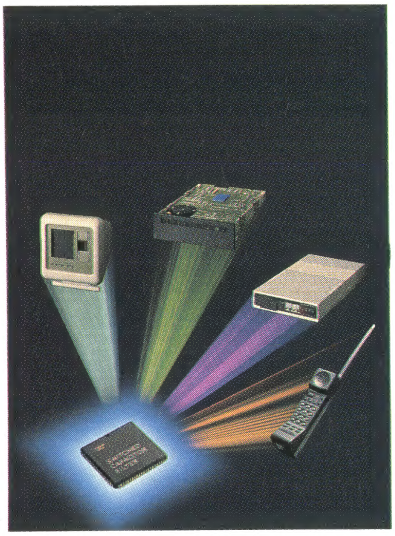
ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Technological improvements to switched-capacitor filter ICs make them suitable for a growing range of applications. The devices offer an alternative to discrete-component filters by providing high-precision, tunable filtering. Turn to our Special Report on pg 86. (Photo courtesy Exar Corp)*

SPECIAL REPORT

Switched-capacitor filter ICs 86

Once considered noisy low-frequency devices suitable only for applications such as voice-grade telephony, switched-capacitor filter ICs have undergone a number of improvements. These compact, tunable devices offer many advantages over discrete-component filters and suit an increasing array of applications. *—Richard A Quinnell, Regional Editor*

DESIGN FEATURES

Designer's guide to flash-ADC testing—Part 1 101

Building high-performance circuits that take advantage of the high sampling rates of flash ADCs requires a knowledge of these converters' many intricacies. Part 1 of this 3-part series discusses the pitfalls of designing with flash ADCs, how to evaluate certain data-sheet specifications, and how to choose external components that complement your particular converter.*—Walt Kester, Computer Labs Div, Analog Devices*

GaAs technology holds promise for high-speed communications 119

Long-haul, point-to-point, and local-area-network (LAN) communications systems require data rates that are outstripping current silicon IC capabilities. However, manufacturers of GaAs ICs can now supply chips that will support high-speed data links. *—Ronald M Hickling and Mark D Warlick, Gigabit Logic*

TECHNOLOGY UPDATES

The industrial PC: Harsh conditions affect industrial PC design 45

Harsh environmental conditions and strict regulatory requirements haven't prevented the implementation of the ubiquitous IBM PC in the industrial workplace. Modified PCs incorporate versatile designs suited specifically to the factory floor.*—John A Gallant, Associate Editor*

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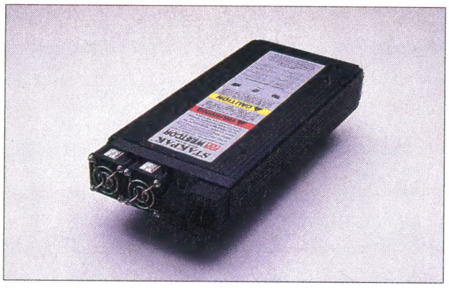
STAKPAK II STANDARD 600 WATT MODELS



Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel				
	#1	#2	#3	#4	#5
Single Output					
ST1-1401	2 @ 120				
ST1-1402	5 @ 120				
ST1-1301	12 @ 50				
ST1-1302	15 @ 40				
ST1-1303	24 @ 25				
ST1-1304	28 @ 21				
ST1-1305	48 @ 13				
Dual Output					
ST2-1401	2 @ 60	5 @ 60			
ST2-1402	5 @ 60	5 @ 60			
ST2-1403	5 @ 60	12 @ 33			
ST2-1404	12 @ 33	12 @ 33			
ST2-1405	15 @ 26	15 @ 26			
Triple Output					
ST3-1401	5 @ 60	12 @ 16	12 @ 16		
ST3-1402	5 @ 60	15 @ 13	15 @ 13		
ST3-1501	5 @ 90	12 @ 8	12 @ 8		
Quad Output					
ST4-1401	5 @ 30	12 @ 16	12 @ 16	5 @ 30	
ST4-1402	5 @ 30	15 @ 13	15 @ 13	5 @ 30	
ST4-1403	5 @ 30	12 @ 16	12 @ 16	24 @ 8	
ST4-1501	5 @ 30	15 @ 13	15 @ 13	24 @ 8	
ST4-1502	5 @ 60	12 @ 16	12 @ 8	5 @ 15	
ST4-1503	5 @ 60	15 @ 13	15 @ 7	5 @ 15	
ST4-1504	5 @ 60	12 @ 16	12 @ 8	24 @ 4	
ST4-1505	5 @ 60	15 @ 13	15 @ 7	24 @ 4	
Five Output					
ST5-1501	5 @ 30	12 @ 16	12 @ 16	5 @ 15	24 @ 4
ST5-1502	5 @ 30	15 @ 13	15 @ 13	5 @ 15	24 @ 4

Total output power may not exceed 600 watts for any model, single or multiple output. Lower power StakPak II models and many other configurations are available. Please contact the factory.

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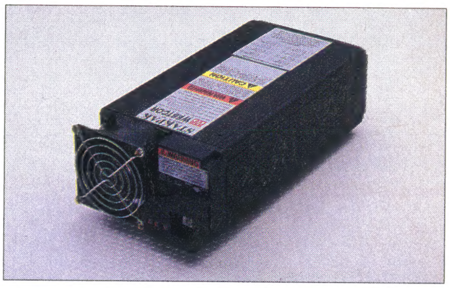
STAKPAK STANDARD 1200 WATT MODELS



Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel				
	#1	#2	#3	#4	#5
Single Output					
SP1-1801	2 @ 240				
SP1-1802	5 @ 240				
SP1-1803	12 @ 100				
SP1-1604	15 @ 80				
SP1-1605	24 @ 50				
SP1-1606	28 @ 42				
SP1-1607	48 @ 25				
Dual Output					
SP2-1801	2 @ 120	5 @ 120			
SP2-1802	5 @ 120	5 @ 120			
SP2-1803	5 @ 120	12 @ 66			
SP2-1804	12 @ 66	12 @ 66			
SP2-1805	15 @ 53	15 @ 53			
Triple Output					
SP3-1801	5 @ 180	12 @ 16	12 @ 16		
SP3-1802	5 @ 150	12 @ 33	12 @ 16		
SP3-1803	5 @ 180	15 @ 13	15 @ 13		
SP3-1804	5 @ 150	15 @ 26	15 @ 13		
Quad Output					
SP4-1801	5 @ 150	12 @ 16	12 @ 16	5 @ 30	
SP4-1802	5 @ 150	15 @ 13	15 @ 13	5 @ 30	
SP4-1803	5 @ 150	12 @ 16	12 @ 16	24 @ 8	
SP4-1804	5 @ 150	15 @ 13	15 @ 13	24 @ 8	
Five Output					
SP5-1801	5 @ 120	12 @ 16	12 @ 16	5 @ 30	24 @ 8
SP5-1802	5 @ 120	15 @ 13	15 @ 13	5 @ 30	24 @ 8
Seven Output					
SP7-1801	5 @ 60	12 @ 16	12 @ 16	24 @ 8	24 @ 8
	#6	#7			
	5.2 @ 28	2 @ 30			

Total output power may not exceed 1200 watts for any model, single or multiple output. Lower power StakPak models and many other configurations are available. Please contact the factory.

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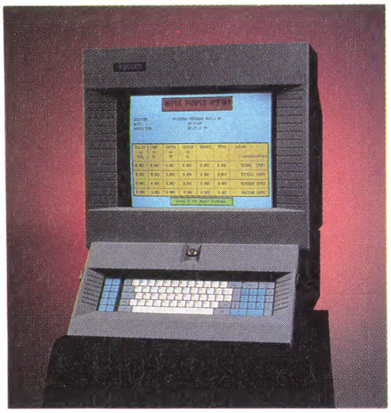

The constraints of the industrial environment *have spawned a new class of computers. The industrial PC features modifications that ensure reliable operation under harsh conditions (pg 45).*

High-bandwidth DSOs push beyond 20 GHz 61

Although two advanced, general-purpose oscilloscopes from Hewlett-Packard and Tektronix share impressive bandwidth specifications, differences in how each samples data, provides histograms, and supports time-domain reflectometry require you to choose carefully between these digital-storage oscilloscopes.
—Doug Conner, Regional Editor

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Express Request

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Two states now have antijunk-FAX laws. Telephone subscribers should have a way to protect against unsolicited phone calls, too.

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Data-compression devices

Brushless dc motors

Buscon/88 East preview

Analog-I/O cards transform PCs into data-acquisition systems

A CAHNERS PUBLICATION

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EDN NEWS EDITION

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Modules yield denser systems

Preassembled subsystems, connectors, and motherboards save space

WILL DAVIES

IC makers grapple with metastability

A call for Ada experts

Although Ada's popularity is growing slowly, the demand for experts exceeds the supply

MICHAEL BALL

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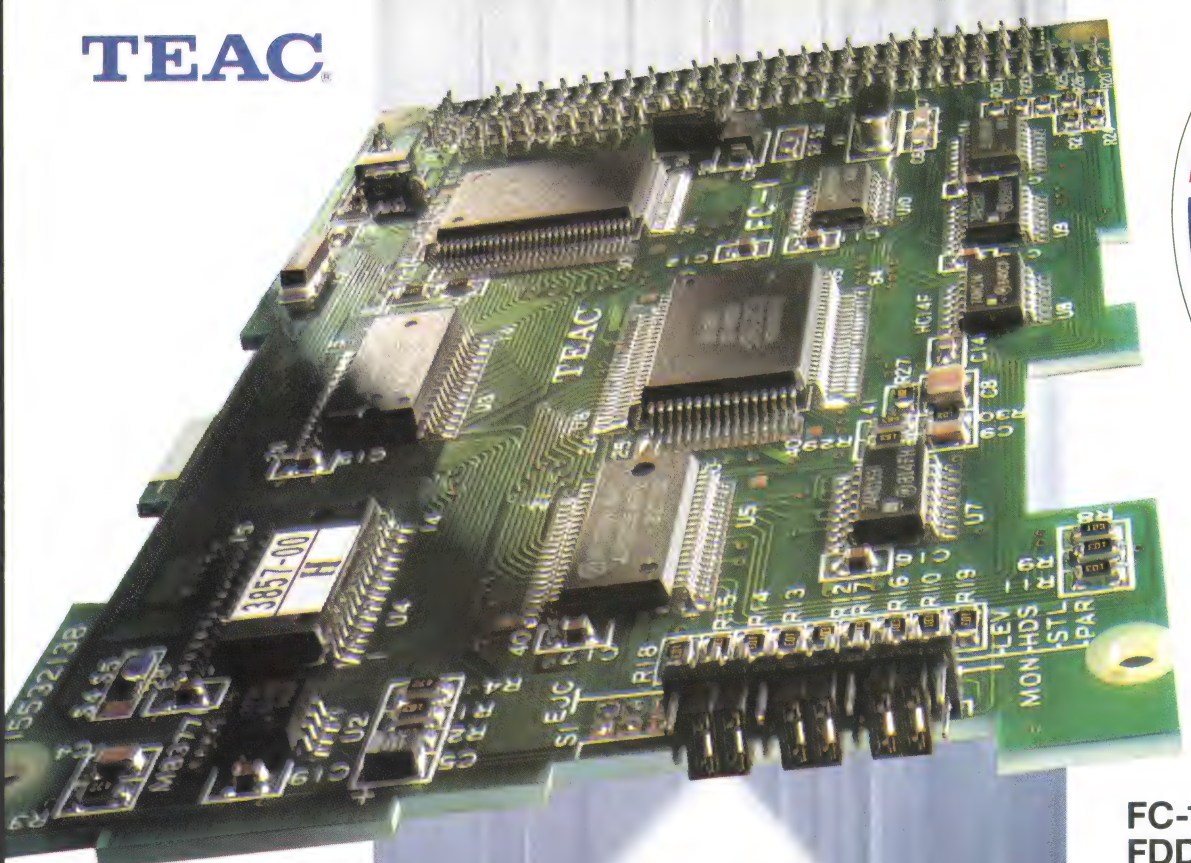

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CIRCLE NO. 27

National Semiconductor

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*The new
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16K x 4 at 10 ns*

*The original
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256K x 1 at 15 ns*

*The new
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64K x 4 at 12 ns*

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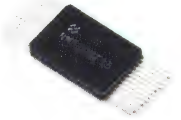
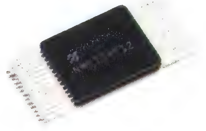
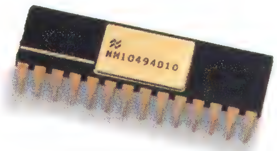


The original BiCMOS 256Kx1 at 15 ns



The new BiCMOS 64Kx4 at 12 ns



The new BiCMOS 16Kx4 at 10 ns

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We've been shipping our 256Kx1 for more than 18 months. Now production quantities are also available of our new 64Kx4 and 16Kx4. And more new SRAMs are on the way.

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ASPECT™ standard cells
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ECL PALs
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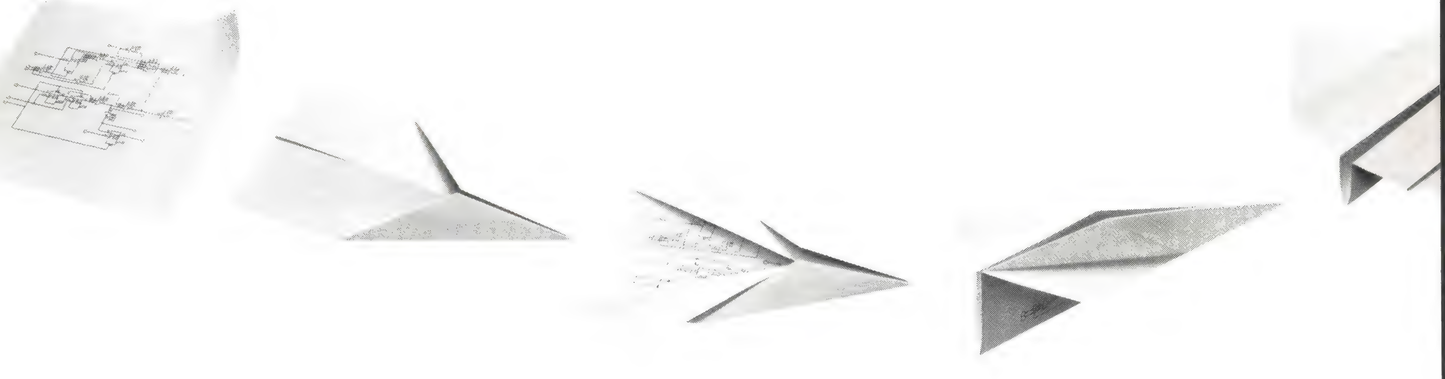
Anyone can make an LCD screen thinner or lighter by taking something out.



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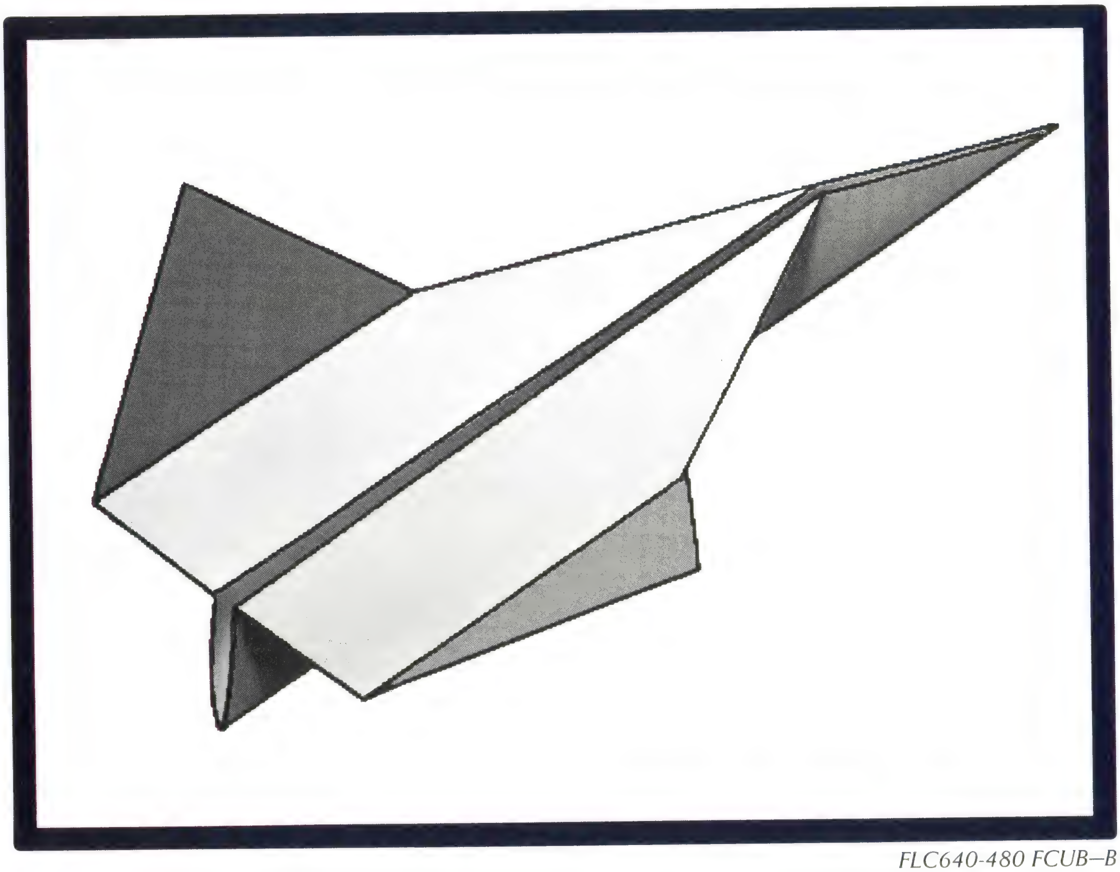

FLC640-480 FCUB—B

Our driver circuitry, for example. Mounted around the edge of the screen by TAB (tape-automated bonding), it helps us trim nearly 7 mm off our bright new CCFL backlit FSTN LCDs. So they're only 20 mm thick.

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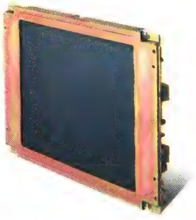
We've even built in a replaceable CCFL lighting system, making Fujitsu FSTN LCDs easier to service.

So if you want thinner, lighter 640 × 480 dot LCD screens for your laptops, portable PCs or other applications, ask for Fujitsu FSTN LCD screens. After all, what you get out of your products depends on what you put into them.



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CIRCLE NO. 32

NEWS BREAKS

EDITED BY JULIE ANNE SCHOFIELD

MONOLITHIC 10-BIT ADCs REACH SPEEDS OF 75M SAMPLES/SEC

Analog Devices' (Norwood, MA, (617) 329-4700) AD9020 (TTL-compatible) and AD9060 (ECL-compatible) 10-bit A/D converters have guaranteed encode rates of 60M and 75M samples/sec, respectively. With an input frequency of 2.3 MHz, the converters have a minimum S/N ratio of 56 dB. Each converter's analog bandwidth is 175 MHz typ. The ADCs feature an interpolation architecture that uses only 512 internal comparators instead of the 1024 comparators used by a standard flash implementation. This architecture reduces the converters' input capacitance to 45 pF typ and improves linearity by spreading their differential nonlinearity over four codes. The T and K grades of each converter have maximum differential nonlinearity of 1 LSB. Both converters accept bipolar, ±1.75V analog inputs. The ADCs' maximum power dissipation, including the resistor ladder, is 3.5W. The converters are available in 68-pin ceramic gull-wing packages or ceramic LCCs; prices start at $165 (100). —Anne Watson Swager

ASIC FEATURES SHRINK BELOW A MICRON

Your ASICs can now be 40% faster and more dense than ASICs designed using NCR Microelectronics' (Fort Collins, CO, (303) 226-9550) 1.5-µm libraries thanks to the company's 0.7-µm effective-channel-width array and cell libraries. These libraries feature user-configurable compiler functions, high-level function macros for personal-computer applications, and analog cells. The company's integrated ASIC/system design-tool suite, which runs on Sun and Apollo workstations, ties the package together. The libraries' modeling capability yields accuracy better than that of earlier generations by letting NCR's simulator calculate delays based on internal input rise and fall times as well as loading effects. The VS700 cell library contains 180 cells. The base wafers support designs of about 100,000 gates/chip. You can use the VGX700 array library on one of three base arrays, each of which has 15,000 to 30,000 usable gates. Later releases of VGX700 will support as many as 70,000 usable gates. The VS700 library is available now; the VGX700 library will be available in May.—Michael C Markowitz

HELICAL-SCAN TAPE DRIVE STORES 5G BYTES

Doubling the number of read and write heads on the helical-scan drum of its tape drive let Exabyte Corp (Boulder, CO, (303) 442-4333) double both the capacity and the transfer rate of its EXB8200 8-mm tape drive. The resulting tape drive, the EXB8500, stores as much as 5G bytes on one 8-mm video-tape cartridge at 500k bytes/sec. The drive's search rate is 37M bytes/sec. The new drive can read and write tapes in the older, lower-capacity EXB8200 tape format. The EXB8500 costs $3895; production shipments will start in the third quarter.

The company also announced the $35,000 EXB-120 CHS robotic tape handler, which holds as many as four tape drives and 116 cartridges. Thus, the unit can store as much as 580G bytes in a unit that measures 17.6×45.5×18.5 in. and requires 3.66 ft^2. Like the tape drives, the robot communicates with a host computer via a SCSI port.—Steven H Leibson

NEWS BREAKS

MODULAR CONNECTOR TACKLES HIGH-FREQUENCY APPLICATIONS

Augat Inc's (Attleboro, MA, (508) 222-2202) modular electronically invisible interconnect (EII) system suits supercomputers, VLSI IC testers, communications equipment, and other devices that operate in the gigahertz range. The system provides a 50Ω-impedance path for signals between a mother board and a perpendicular daughter card. You can add power and ground contacts as you need them. The power contacts handle 10A at 5V and do not arc during powered board insertion or removal. The signal connections are available in blocks of 160 lines. The connector uses a gold-to-gold pressure contact on the mother board and the daughter board. The connector can withstand a minimum of 100 insertion/removal cycles. Augat expects to have connectors in production in the third quarter of 1990. A sample kit that includes a test connector and sample test boards is available now for $1000.
—Jon Titus

2-CHIP SET IMPLEMENTS SECONDARY CACHE FOR 80486 μP

Although Intel's 80486 μP features an 8k-byte cache memory, you may find that you need a larger, secondary cache for some applications. A 2-chip set comprising the C415 cache interface adapter and the C395e 32-bit cache controller from Matra Design Semiconductor (Santa Clara, CA, (408) 986-9000, FAX (408) 748-1038) implements a secondary cache controller for the 80486 μP. With these two ICs and an appropriate number of static RAMs, you can build a 128k- or 256k-byte secondary cache. The chip set supports 4-way, set-associative memory mapping and will optionally support direct-mapped and 2-way, set-associative mapping schemes. These cache-memory chips also offer you a choice of copy-back and write-through schemes. The 25-MHz version of the 2-chip set costs $198 (100).—Steven H Leibson

I/O BOARD ASSUMES HEAVY RESPONSIBILITIES

CacheFlow, a multifunction full-slot IBM PC/AT card from Intelligent Access (Foster City, CA, (415) 570-4608), replaces an existing PC/AT-bus's disk controller and shoulders a host of I/O chores. The board features a SCSI port capable of handling as many as eight devices, two ST506 hard-disk connector ports, two floppy-disk-drive control ports, an RS-232C port, and a parallel port. An onboard V40 μP and 512k bytes of cache memory manage as many as five simultaneous I/O operations. Because the main CPU and bus aren't required for all operations, your system can automatically provide functions like hard-disk backup without interrupting you or significantly slowing hard-disk response to your commands. CacheFlow will cost about $300 and will be available in the first quarter of 1990.—Michael C Markowitz

VFD DRIVER IC PROVIDES ON-CHIP DIMMING CONTROL CIRCUIT

Simplifying your circuit design, the MSC1187 vacuum-fluorescent-display (VFD) driver chip from Oki Semiconductor (Sunnyvale, CA, (408) 737-6345) integrates all the components needed to control the brightness of VFDs. The IC has a serial interface that accepts the clock, data, and load-pulse information needed to determine the required PWM output for a specific display intensity. Housed in a 44-pin flatpack, the MSC1187 costs $4 (10,000). An NRE cost of $5000 lets you specify the chip's dimming curve. Delivery is 12 weeks ARO.—J D Mosley

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Fact: Shrink Wrapped Applications. SPARC is the only RISC architecture that is truly open, with available, binary-compatible clones. The shrink-wrapped UNIX® applications base — including the leading database, publishing, office and engineering packages — is larger than for ALL of the other RISC architectures combined. And with major new support announcements from Lotus, Santa Cruz Operations (SCO), and Wordperfect, expect significant new applications. Applications drive the industry's next computing standard.

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NEWS BREAKS

SURFACE-MOUNT CONNECTORS INCLUDE POSITIONING PEGS

Providing the stability to withstand wave soldering without shifting or raising, the Pegasus gull-wing surface-mount-technology headers from Crane Electronics (Cincinnati, OH, (513) 563-1161) have an optional peg that securely attaches the connector to your pc board. The headers' plastic can withstand 240°C at 264 psi. These headers have 40-mil holes in the insulator between contact pins. The interior holes let pick-and-place equipment handle the connector without grasping its outer surface, thereby saving board real estate and eliminating any possibility of dislodging other components located close to the header. To ensure stronger solder joints, the contacts are square with rounded bullet-shaped tips. You can order tin- or gold-plated contacts. A dual-row 10-position header with gold-plated posts costs $0.56 (1000).—J D Mosley

IC SIMULATES SPEECH FOR LESS THAN $2

For less than $2 in OEM quantities you can purchase a chip that integrates an 8-bit µP and a speech synthesizer. The TSP50C10 from Texas Instruments (Dallas, TX, (800) 232-3200, ext 700) has an 8k × 8-bit ROM that stores 20 to 50 words and the company's LPC-12 linear-predictive-coding algorithm. For applications that require larger vocabularies, you can purchase 250k-bit and 1M-bit speech ROMs for off-chip storage. The TSP50C10's µP fetches speech data at rates as low as 1k bps, decodes the data, and then sends it to the synthesizer, which performs digital low-pass filtering. The µP performs 61 instructions and can execute a single-cycle multiplication operation in 1.6 µsec. In addition to speech, the chip can also produce music and sound effects.—J D Mosley

BEHAVIORAL MODELS AVAILABLE FOR FPGAs

Behavioral models are available from Logic Automation (Beaverton, OR, (503) 690-6900) for the 2000 and 3000 series field-programmable gate arrays (FPGAs) from Xilinx (San Jose, CA, (408) 559-7778). Because these models join a library of over 5000 SmartModels of devices including microprocessors and RAM, you can now simulate complete system-level designs much faster than with gate-level simulation. Logic Automation's SmartModels run on most popular digital simulators and let you mix behavioral and gate-level models for designs where behavioral models are not available. You can license the SmartModel library, including the Xilinx FPGA parts, through Logic Automation's annual subscription service for $7900 per workstation. The $4000 SmartModel windows option lets you read from and write to internal registers in the FPGA's logic cells.—Doug Conner

MOUSE/DIGITIZER PAD OFFERS 1000-DPI RESOLUTION

The Wiz from Calcomp (Anaheim, CA, (714) 821-2142) marries a 3-button mouse and a digitizing tablet and sells for $249. The mouse features a cross-hair target for accurate digitizing, and the mouse pad is actually a digitizing tablet that enables the device to achieve a resolution of 1000 dpi. The company offers versions of the product for IBM PCs and Apple Macintoshes. It plans to offer a series of $49 plastic templates and associated software to enhance the device's performance for specific application programs and a $75 digitizing pen that can replace the mouse for applications that require extensive digitizing.—Steven H Leibson

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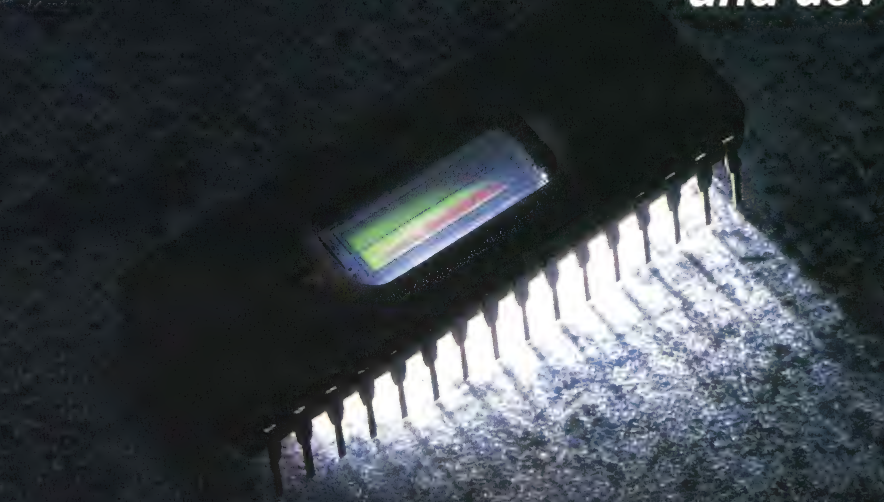

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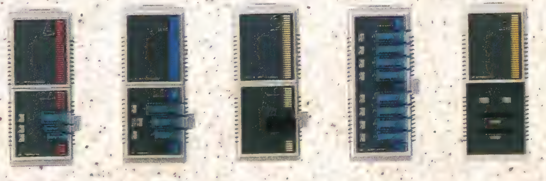

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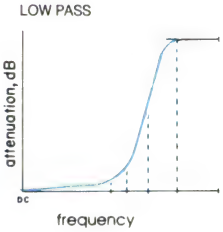
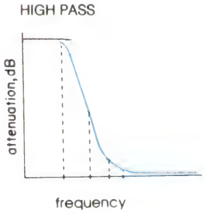


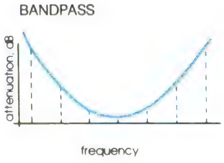
low pass dc to 1200MHz

MODEL NO.	PASSBAND, MHz (loss <1dB) Min.	fco, MHz (loss 3db) Nom.	STOP BAND, MHz (loss>20dB) Max.	STOP BAND, MHz (loss>40dB) Max.	STOP BAND, MHz (loss>40dB) Min.	VSWR pass-band typ.	VSWR stop-band typ.	PRICE $ Qty. (1-9)
PLP-10.7	DC-11	14	19	24	200	1.7	18	11.45
PLP-21.4	DC-22	24.5	32	41	200	1.7	18	11.45
PLP-30	DC-32	35	47	61	200	1.7	18	11.45
PLP-50	DC-48	55	70	90	200	1.7	18	11.45
PLP-70	DC-60	67	90	117	300	1.7	18	11.45
PLP-100	DC-98	108	146	189	400	1.7	18	11.45
PLP-150	DC-140	155	210	300	600	1.7	18	11.45
PLP-200	DC-190	210	290	390	800	1.7	18	11.45
PLP-250	DC-225	250	320	400	1200	1.7	18	11.45
PLP-300	DC-270	297	410	550	1200	1.7	18	11.45
PLP-450	DC-400	440	580	750	1800	1.7	18	11.45
PLP-550	DC-520	570	750	920	2000	1.7	18	11.45
PLP-600	DC-580	640	840	1120	2000	1.7	18	11.45
PLP-750	DC-700	770	1000	1300	2000	1.7	18	11.45
PLP-800	DC-720	800	1080	1400	2000	1.7	18	11.45
PLP-850	DC-780	850	1100	1400	2000	1.7	18	11.45
PLP-1000	DC-900	990	1340	1750	2000	1.7	18	11.45
PLP-1200	DC-1000	1200	1620	2100	2500	1.7	18	11.45



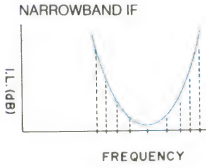
high pass dc to 2500MHz

MODEL NO.	PASSBAND, MHz (loss <1dB) Min.	PASSBAND, MHz (loss <1dB) Min.	fco, MHz (loss 3db) Nom.	STOP BAND, MHz (loss>20dB) Min.	STOP BAND, MHz (loss>40dB) Min.	VSWR pass-band typ.	VSWR stop-band typ.	PRICE $ Qty. (1-9)
PHP-50	41	200	37	26	20	1.5	17	14.95
PHP-100	90	400	82	55	40	1.5	17	14.95
PHP-150	133	600	120	95	70	1.8	17	14.95
PHP-175	160	800	140	105	70	1.5	17	14.95
PHP-200	185	800	164	116	90	1.6	17	14.95
PHP-250	225	1200	205	150	100	1.3	17	14.95
PHP-300	290	1200	245	190	145	1.7	17	14.95
PHP-400	395	1600	360	290	210	1.7	17	14.95
PHP-500	500	1600	454	365	280	1.9	17	14.95
PHP-600	600	1600	545	440	350	2.0	17	14.95
PHP-700	700	1800	640	520	400	1.6	17	14.95
PHP-800	780	2000	710	570	445	2.1	17	14.95
PHP-900	910	2100	820	660	520	1.8	17	14.95
PHP-1000	1000	2200	900	720	550	1.9	17	14.95



bandpass 20 to 70MHz

MODEL NO.	CENTER FREQ. MHz F0	PASS BAND, MHz (loss <1dB) Max. F1	PASS BAND, MHz (loss <1dB) Min. F2	STOP BAND, MHz (loss > 10 dB) Min. F3	STOP BAND, MHz (loss > 10 dB) Max. F4	STOP BAND, MHz (loss > 20 dB) Min. F5	STOP BAND, MHz (loss > 20 dB) Max. F6	VSWR 1.3:1 typ. total band MHz	PRICE $ Qty. (1-9)
PIF-21.4	21.4	18	25	4.9	85	1.3	150	DC-220	14.95
PIF-30	30	25	35	7	120	1.9	210	DC-330	14.95
PIF-40	42	35	49	10	168	2.6	300	DC-400	14.95
PIF-50	50	41	58	11.5	200	3.1	350	DC-440	14.95
PIF-60	60	50	70	14	240	3.8	400	DC-500	14.95
PIF-70	70	58	82	16	280	4.4	490	DC-550	14.95



narrowband IF

MODEL NO.	CENTER FREQ. MHz F0	PASS BAND, MHz I.L. 1.5dB max. F1-F2	STOP BAND, MHz I.L. > 20dB F5	STOP BAND, MHz I.L. > 20dB F6	STOP BAND, MHz I.L. > 35dB F7	STOP BAND, MHz I.L. > 35dB F8-F9	PASS-BAND VSWR Max.	PRICE $ Qty. (1-9)
PBP-10.7	10.7	9.5-11.5	7.5	15	0.6	50-1000	1.7	18.95
PBP-21.4	21.4	19.2-23.6	15.5	29	3.0	80-1000	1.7	18.95
PBP-30	30.0	27.0-33.0	22	40	3.2	99-1000	1.7	18.95
PBP-60	60.0	55.0-67.0	44	79	4.6	190-1000	1.7	18.95
PBP-70	70.0	63.0-77.0	51	94	6	193-1000	1.7	18.95

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MSM514102-10XX			100
MSM514400-8XX	1M x 4	Fast Page	80
MSM514400-10XX			100
MSM514402-8XX	1M x 4	Static Column	80
MSM514402-10XX			100
Packaging Options Include: XX = 'JS'...350 mil SOJ 'RS'...400 mil DIP 'ZS'...400 mil ZIP			
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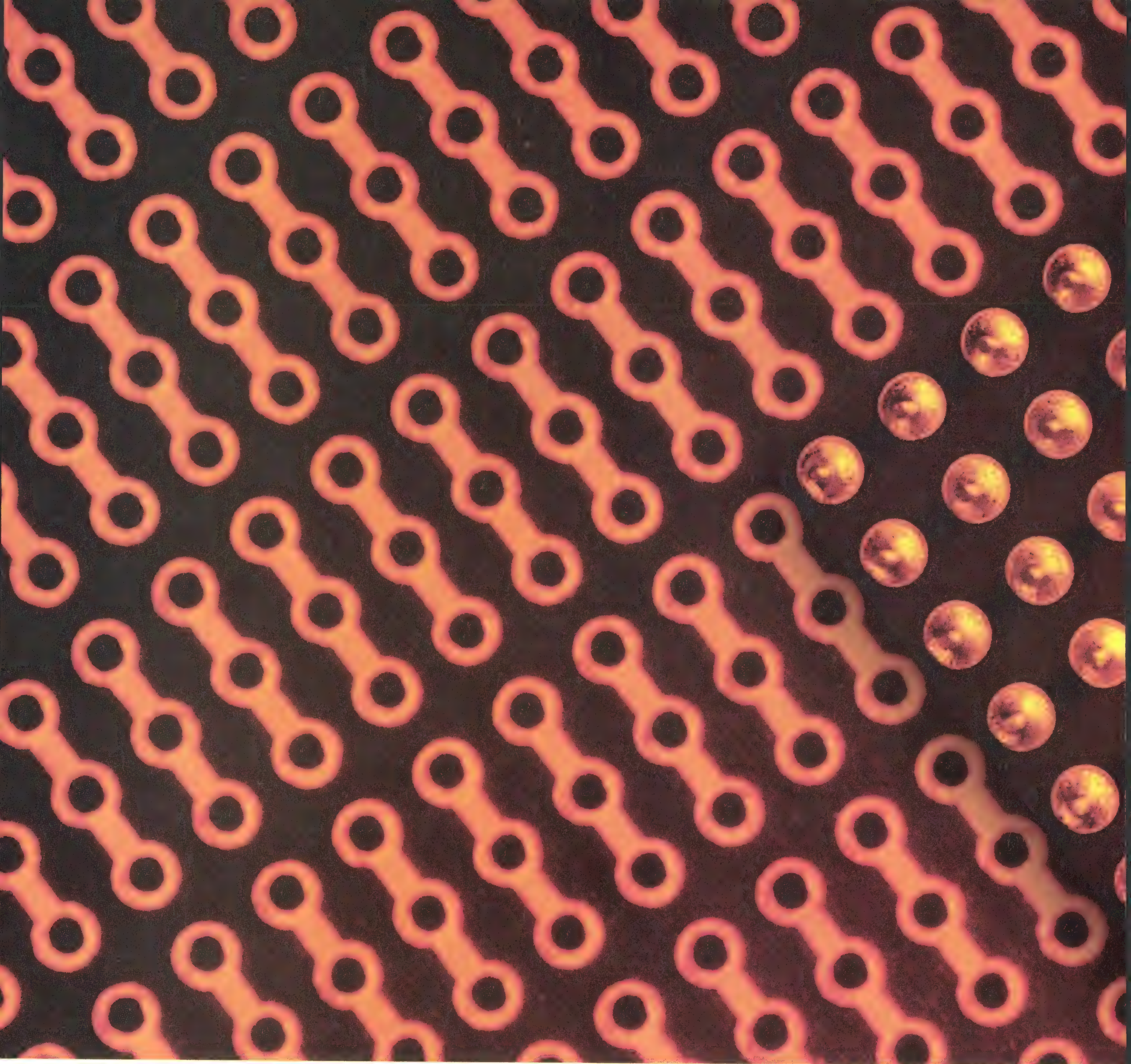

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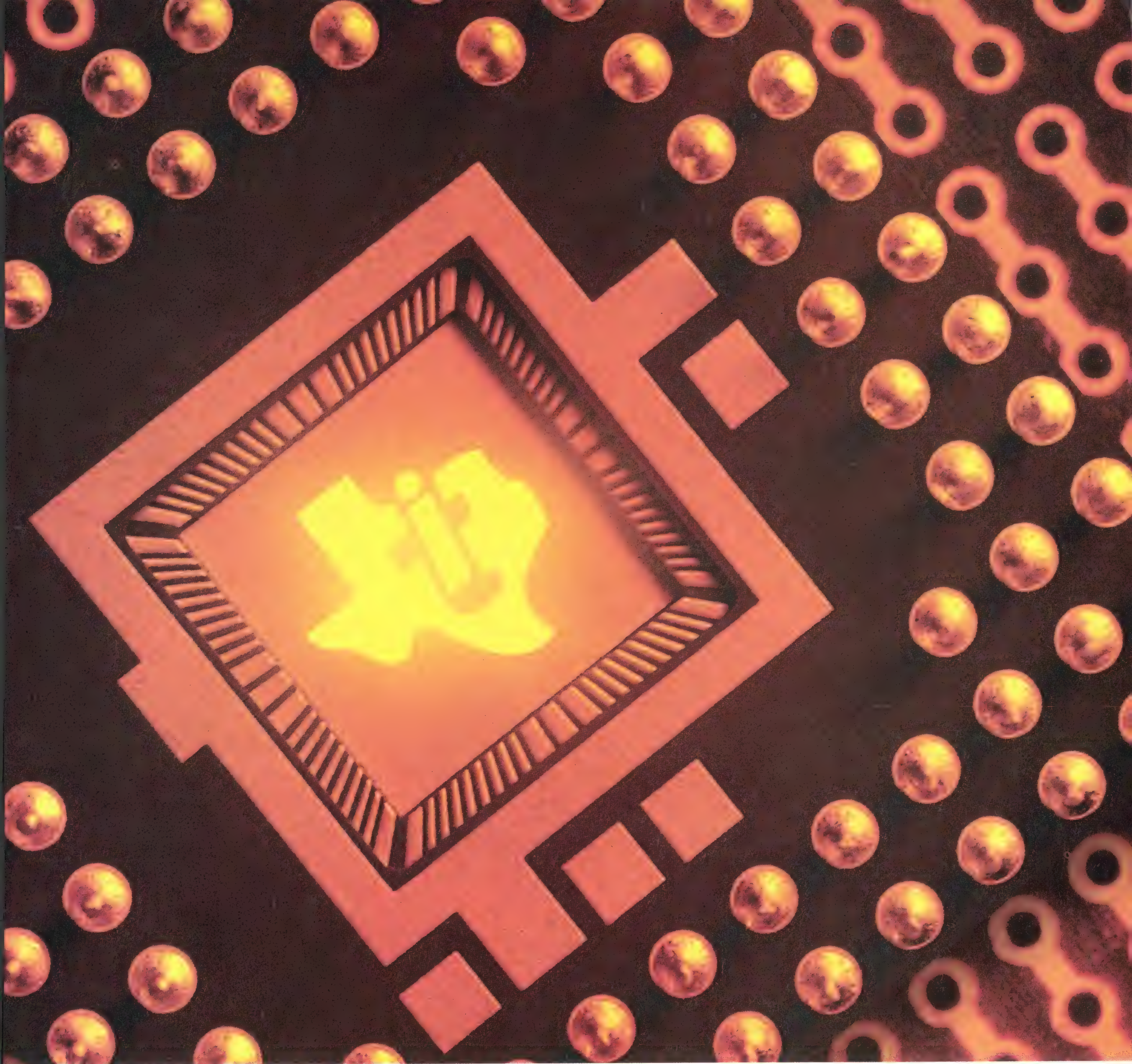

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CIRCLE NO. 37

SIGNALS & NOISE

Number please

On pg 250 of EDN's October 26, 1989, issue, we inadvertently omitted a Reader Service number for John Fluke Mfg Co's Model 2287A analog front end for PC-based data-acquisition systems. For more information, Circle No. 351 on this issue's Reader Service card.

Clearing up analysis misunderstanding

I wish to thank Steve Hageman for his words of praise (EDN, September 1, 1989, pg 40) for my article on capacitively loaded op-amp circuits (EDN, June 8, 1989, pg 147). He also makes two statements that I'd like to correct.

First, he states that my analysis assumes an infinite gain-bandwidth (GBW) product. In fact, in the example discussed at the end of the article, I assume a *finite* GBW of 10 MHz. We can infer this both from the data in the last three lines of the article and from the presence of a second breakpoint in the closed-loop frequency response in **Fig 4**. Had I assumed an infinite GBW in my Spice simulation, this breakpoint would not have been there.

Second, he claims that my analysis accuracy degrades rapidly for circuits having a GBW of <100 kHz. [This statement] is in conflict with the very essence of neutral compensation, whose objective is to ensure a *flat* feedback factor β, regardless of the op-amp dynamics. To corroborate my results, I repeated the Spice simulation of the circuit, but using an op amp with a GBW of 100 kHz. As expected, I found neither ringing in the transient response, nor peaking in the frequency response, thus confirming a still stable circuit. The reduced GBW simply slows down the transient response and moves the second breakpoint down to 10 kHz, thus reducing the closed-loop bandwidth.

Criticism is always useful because it either helps correct mistakes, or it corroborates what is already correct.

Sergio Franco
Professor of Electrical Engineering
San Francisco State University
San Francisco, CA

Correction

In **Table 1** of the Special Report on "8- and 16-bit Microcontrollers" (EDN, September 28, 1989, pg 116), the first company mentioned is "Mitsubishi (Continued)." The entry should read "Motorola" for Models MC68HC05B6 through MC68HC11E9/711E9.

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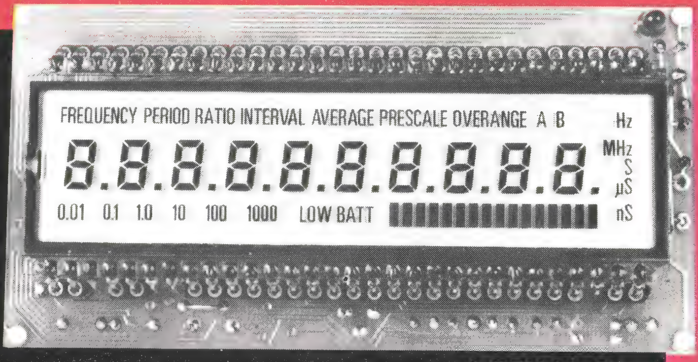
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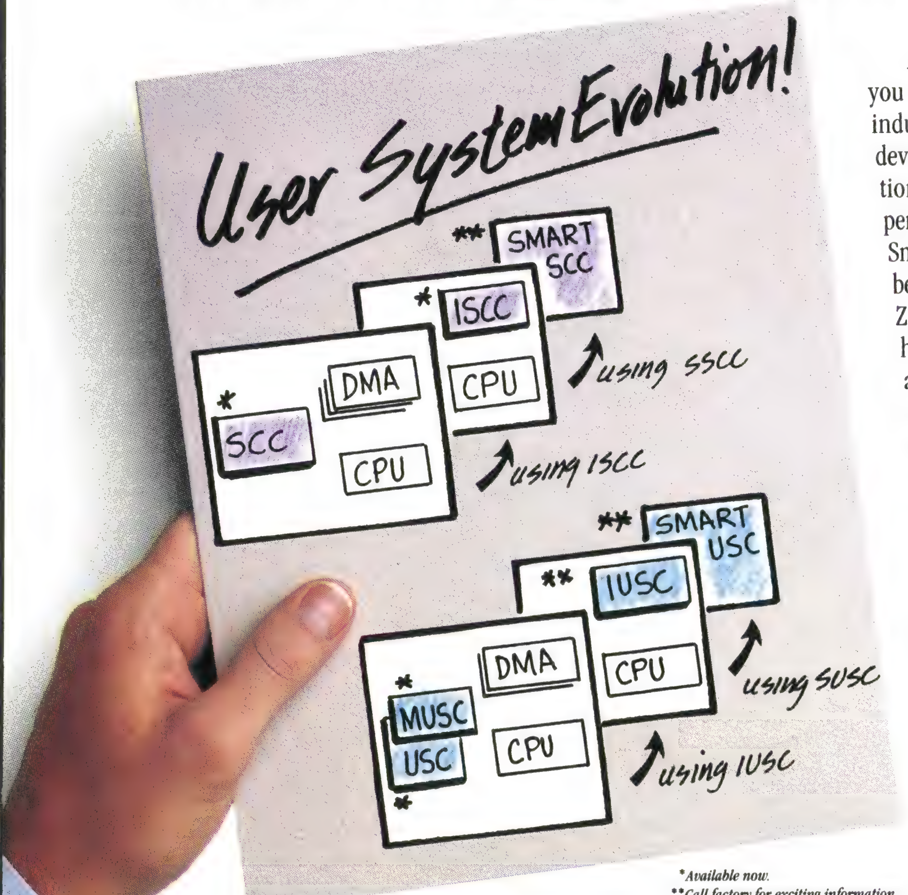

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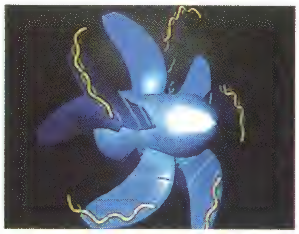
Computational fluid dynamics

Video animation production

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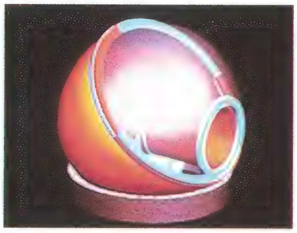
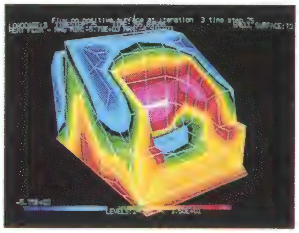
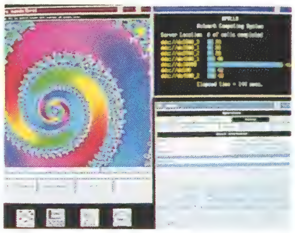
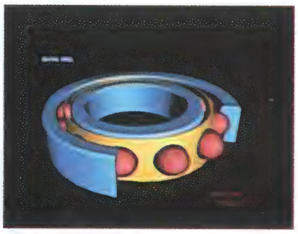
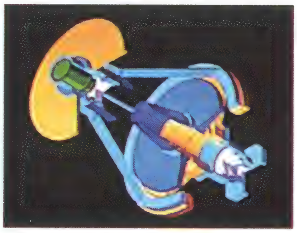
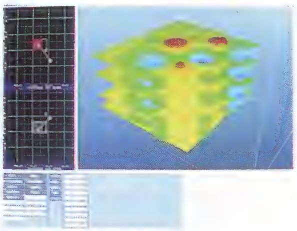

Computer-aided engineering

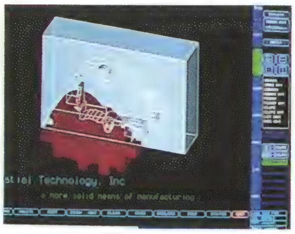

Finite element modeling and analysis


Network computing and mathematics


Computer-aided engineering


Aerospace engineering


Seismic analysis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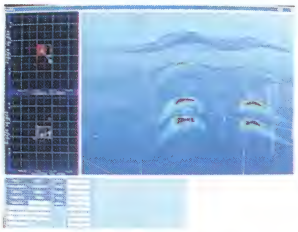
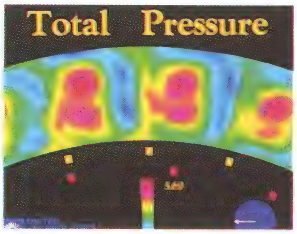

Reservoir analysis



Computational fluid dynamics

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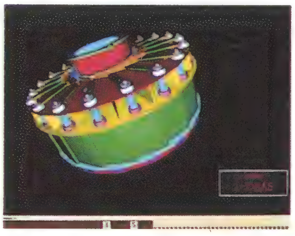
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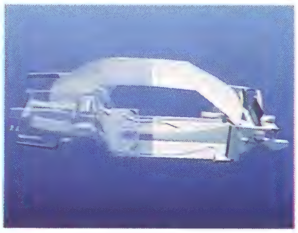
Automotive industrial design

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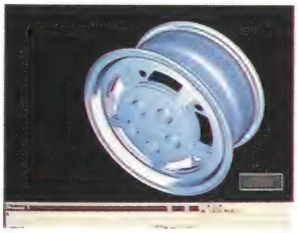
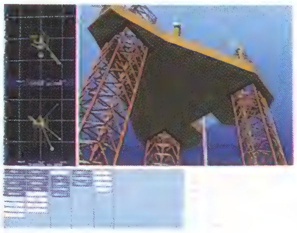
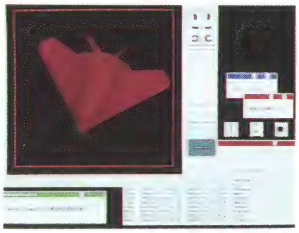
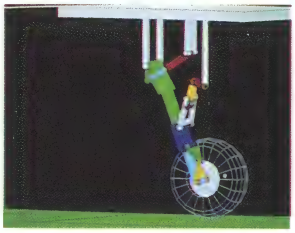

Mechanical design


Scientific visualization


Aerospace engineering


Kinematics and dynamics

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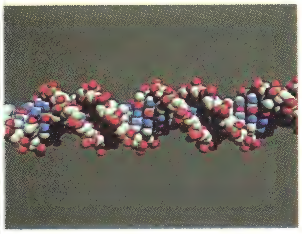
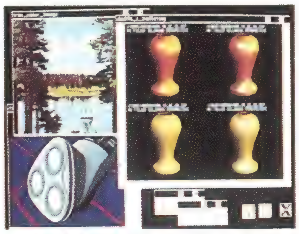
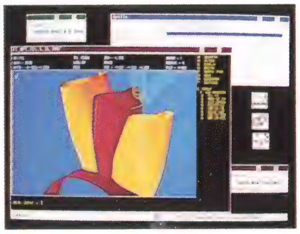
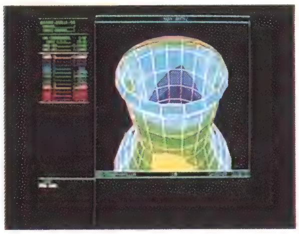
available for any network.

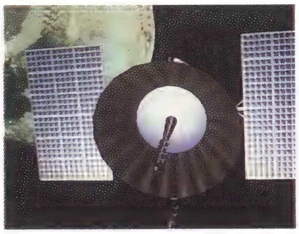

Computer-aided molecular design

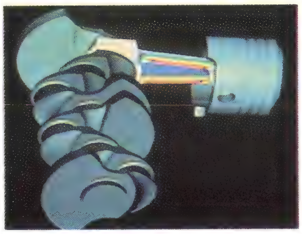

Multi-window industrial design


Computer-aided engineering and design

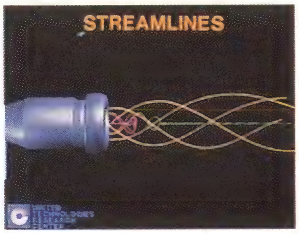
Industrial design


Structural analysis using finite element analysis

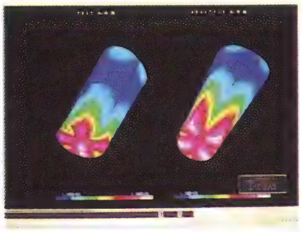

Aerospace engineering

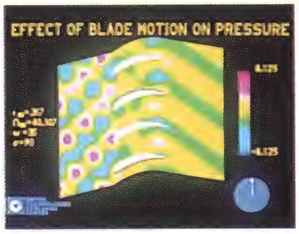

Computer-aided engineering

Automotive engineering



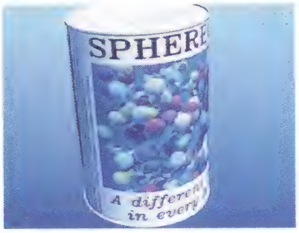
Computational fluid dynamics


Thermal analysis

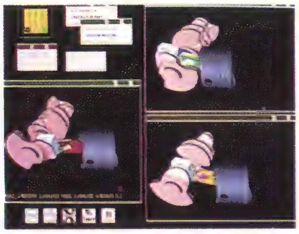


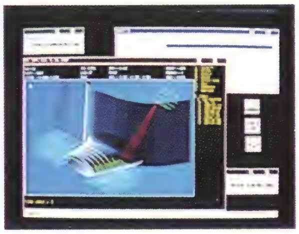
Computational fluid dynamics

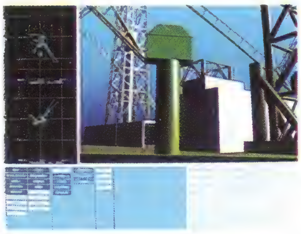
Industrial design

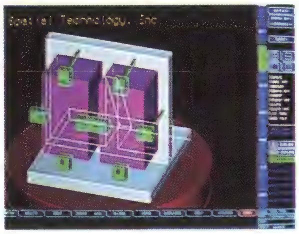


Industrial design

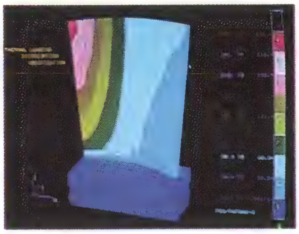

Computer-aided engineering


Computer-aided engineering


Scientific visualization



Computer-aided design


Finite element analysis

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The Series 10000

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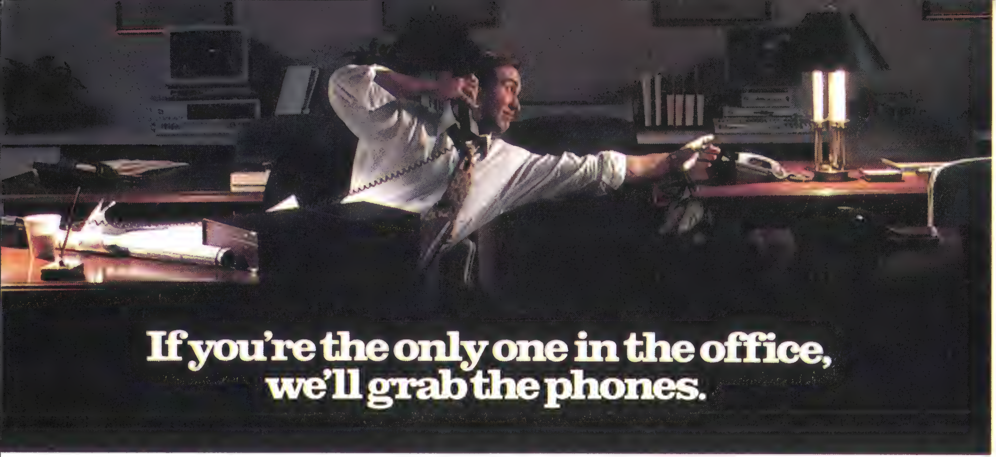
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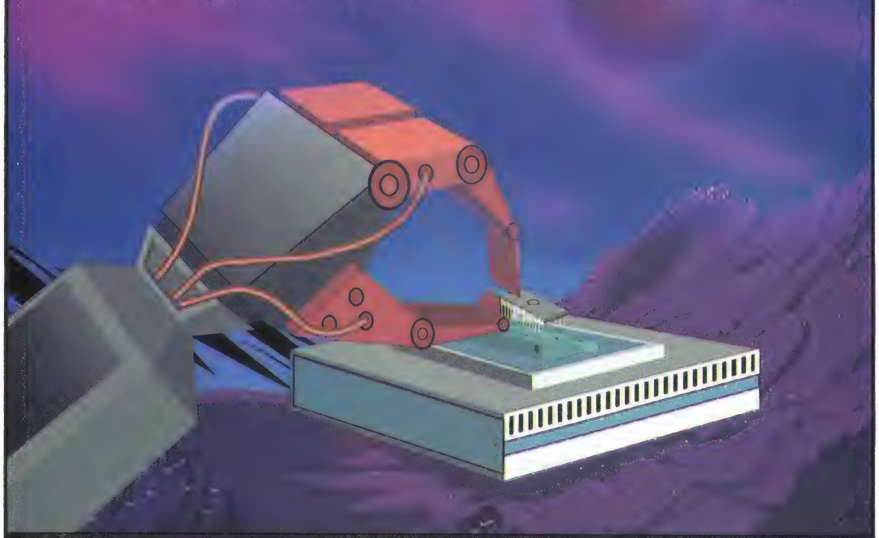

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CALENDAR

Designing for Electromagnetic Compatibility (short course), Various locations and dates. Hewlett-Packard Co, Signal Analysis Div, 1212 Valley House Dr, Rohnert Park, CA 94928. (800) 247-3382; in CA, (707) 794-1212. Through June 5

ATE & Instrumentation West, Anaheim, CA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. January 9 to 11.

Supercomputing Europe '90, London, UK. In the US, Mr Gerry Parker, Meridien Pacific Group, 116 E Blitdale Ave, Suite 2, Mill Valley, CA 94941. (415) 381-2256. FAX 415-381-1451. In Europe, Mr Fetze Pijlman, Royal Dutch Fairs, Box 8500, 3503 RM Utrecht, The Netherlands. (31) 30-955285. FAX 31-30-940379. January 10 to 12.

OE/LASE '90—Optics, Electro-Optics, & Laser Applications in Science and Engineering/Exhibit, Los Angeles, CA. The International Society for Optical Engineering, Box 10, Bellingham, WA 98227. (206) 676-3290. FAX 206-647-1445. January 14 to 19.

Winter 1990 UNIX Technical Conference, Washington, DC. Judith DesHarnais, USENIX Conference Office, 22672 Lambert St, Suite 613, El Toro, CA 92630. (714) 588-8649. January 22 to 26.

SaudiComputer '90, Saudi Arabia. Gerald G Kallman, Kallman Associates, 5 Maple Ct, Ridgewood, NJ 07450. (201) 652-7070. FAX 201-652-3898. January 28 to February 1.

SECS Communications Seminar, Dallas, TX, February 2; San Jose, CA, February 26. GW Associates Inc, 1183 Bordeaux Dr, Suite 27, Sunnyvale, CA 94089. (408) 745-1844.

CIRCLE NO. 42

Seagate's ST1096 Family

THE FINE ART OF DISC DRIVES

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Even to the experienced observer, a disc drive is a technological marvel. With discs spinning at 60 revolutions per second, the mechanics involved are astounding. It takes a company with a unique level of skill and experience to produce drives in volume that perform reliably year after year. A company like Seagate.

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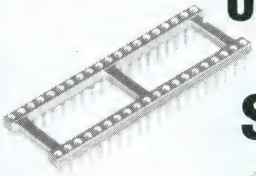
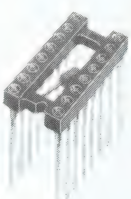
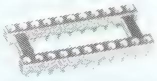

Sockets with pins
- High production, low cost
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- End-to-end and side-to-side stackable
- Solder tail and 2 & 3 wrap pin styles

Sizes
6, 8, 14, 16, 18, 20, 24, 28 pins on .300 centers
20, 22, 24 pins on .400 centers
24, 28, 32, 40, 48 pins on .600 centers
50 and 64 pins on .900 centers

Sockets for SMT (all sizes)

Sockets with capacitors
- Available with either .1μF or .33μF capacitor
- Machine insertable
- Platform UL94VO rated
- Capacitor protects against momentary voltage surges
- Solder tail, 2 and 3 wrap pin styles

Sizes
8, 14, 16, 18, 20, 22, 24, 28 pins on .300 centers
20, 22, 24 pins on .400 centers
24, 28, 32, 40, on .600 centers

See EEM Vol. C, pgs. 1278-1283

CIRCLE NO. 44

CALENDAR

1990 6th IEEE/CHMT Semiconductor Thermal & Temperature Measurement Symposium, Scottsdale, AZ. C/S Communications, Box 23899, Tempe, AZ 85285. (602) 967-7444. February 4 to 8.

2nd International Tape Automated Bonding (TAB) Symposium, San Jose, CA. Dr Subash Khadpe, Semiconductor Technology Center, Box 38, Neffs, PA 18065. (215) 799-0919. FAX 215-799-2677. February 5 to 7.

Communication Networks '90, Washington, DC. IDG Conference Management Group, Box 9171, 20 Speen St, Framingham, MA 01701. (508) 879-6700. February 5 to 8.

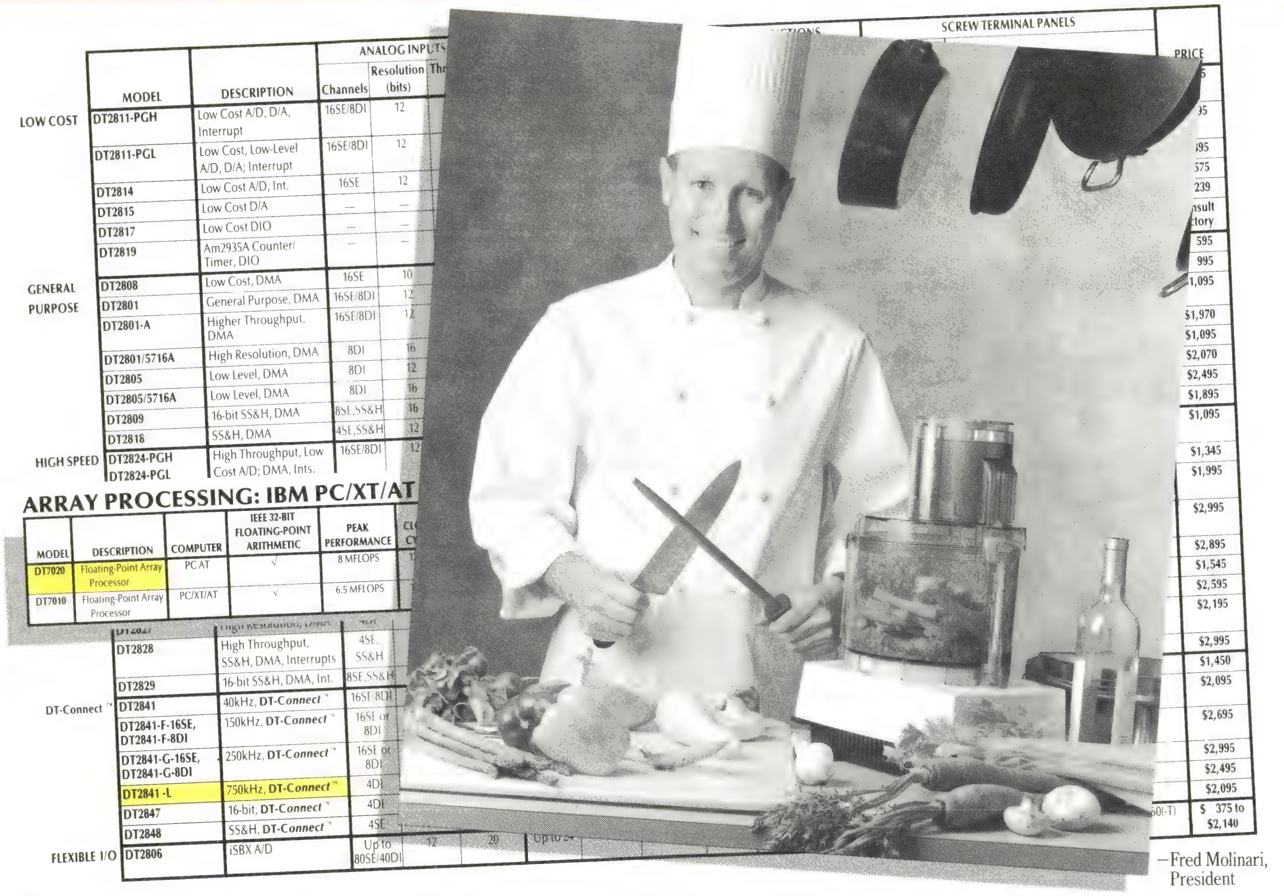
Hands-on UNIX for Programmers (short course), Seattle, WA. Specialized Systems Consultants Inc, Box 55549, Seattle, WA 98155. (206) 527-3385. FAX 206-527-2806. February 7 to 9.

1990 Symposium on Electronic Imaging: Science and Technology/Exhibit, Santa Clara, CA. The International Society for Optical Engineering, Box 10, Bellingham, WA 98227. (206) 676-3290. FAX 206-647-1445. February 11 to 16.

IEEE Instrumentation and Measurement Technology Conference, San Jose, CA. Robert Myers, IEEE Instrumentation and Measurement Society and IEEE Santa Clara Valley Section, 3685 Motor Ave, Suite 240, Los Angeles, CA 90034. (213) 287-1463. FAX 213-287-1851. February 13 to 15.

Modern Power Conversion Design Techniques (short course), San Diego, CA. Joy Bloom, Bloom Associates Inc, Educational Div, 115 Duran Dr, San Rafael, CA 94903. (415) 492-1239. FAX 415-492-1239. February 19 to 23.

IBM PC Data Acquisition Highlights. **No. 3 in a series.**



	MODEL	DESCRIPTION	ANALOG INPUTS Channels	Resolution (bits)
LOW COST	DT2811-PGH	Low Cost A/D, D/A, Interrupt	16SE/8DI	12
	DT2811-PGL	Low Cost, Low-Level A/D, D/A; Interrupt	16SE/8DI	12
	DT2814	Low Cost A/D, Int.	16SE	12
	DT2815	Low Cost D/A	—	—
	DT2817	Low Cost DIO	—	—
	DT2819	Am2935A Counter/ Timer, DIO	—	—
GENERAL PURPOSE	DT2808	Low Cost, DMA	16SE	10
	DT2801	General Purpose, DMA	16SE/8DI	12
	DT2801-A	Higher Throughput, DMA	16SE/8DI	12
	DT2801/5716A	High Resolution, DMA	8DI	16
	DT2805	Low Level, DMA	8DI	12
	DT2805/5716A	Low Level, DMA	8DI	16
	DT2809	16-bit SS&H, DMA	8SE, SS&H	16
	DT2818	SS&H, DMA	4SE, SS&H	12
HIGH SPEED	DT2824-PGH DT2824-PGL	High Throughput, Low Cost A/D; DMA, Ints.	16SE/8DI	12
	DT2828	High Throughput, SS&H, DMA, Interrupts	4SE, SS&H	
	DT2829	16-bit SS&H, DMA, Int.	8SE, SS&H	
DT-Connect™	DT2841	40kHz, **DT-Connect**™	16SE 8DI	
	DT2841-F-16SE, DT2841-F-8DI	150kHz, **DT-Connect**™	16SE or 8DI	
	DT2841-G-16SE, DT2841-G-8DI	250kHz, **DT-Connect**™	16SE or 8DI	
	DT2841-L	750kHz, **DT-Connect**™	4DI	
	DT2847	16-bit, **DT-Connect**™	4DI	
	DT2848	SS&H, **DT-Connect**™	4SE	
FLEXIBLE I/O	DT2806	iSBX A/D	Up to 80SE/40DI	12

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MODEL	DESCRIPTION	COMPUTER	IEEE 32-BIT FLOATING-POINT ARITHMETIC	PEAK PERFORMANCE
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DT7010	Floating-Point Array Processor	PC/XT/AT	√	6.5 MFLOPS

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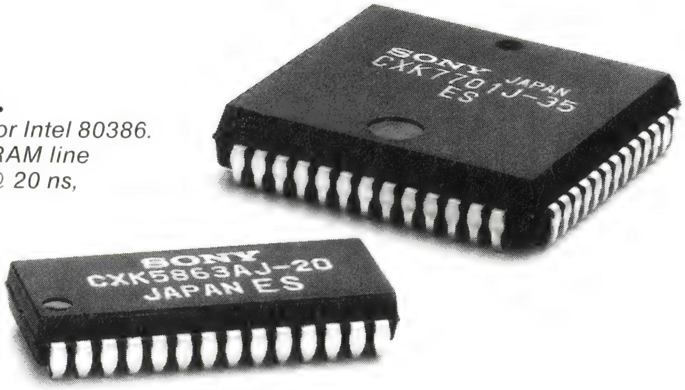
Cache memory for Intel 80386.
Also standard SRAM line
down to 8K x 8 @ 20 ns,
16K x 4 @ 15 ns.



What you see here is a demonstration of Sony's intense commitment to your each and every SRAM need.

A commitment made even more impressive by the fact Sony's only been engineering and producing SRAMs for just over five years.

And when you consider we're pouring all our resources into SRAM technology—including a new production facility in Nagasaki, Japan—this demonstration merely hints at the Sony SRAM technology yet to come.

Ultra-high speed cache.

Via a unique 0.8-micron process, Sony covers your fast processor cache-memory needs two distinct ways.

First, there's our Model CXK7701J, designed specifically for the Intel 80386.

This application-specific memory (ASM) combines address latch, memory and transceiver within one IC. Ready for user configuration as either an 8k x 16-bit memory or as two 4k x 16-bit memories.

ULTRA-HIGH SPEED CACHE SRAMS			
MODEL	CONFIG.	SPEED (ns)	PACKAGE
CXK7701J*	8K x 16	30/35/45/55	PLCC
CXK5863AP	8K x 8	20/25/35	DIP 300 mil
CXK5863AJ	8K x 8	20/25/35	SOJ 300 mil
CXK5466P	16K x 4	15/20	DIP 300 mil
CXK5466J	16K x 4	15/20	SOJ 300 mil
CXK5467P**	16K x 4	15/20	DIP 300 mil
CXK5467J**	16K x 4	15/20	SOJ 300 mil

*For Intel 80386. **O/E

Second, consider our new ultra-high speed SRAM capabilities.

As you scan the chart above, keep in mind even higher speeds will be available soon.

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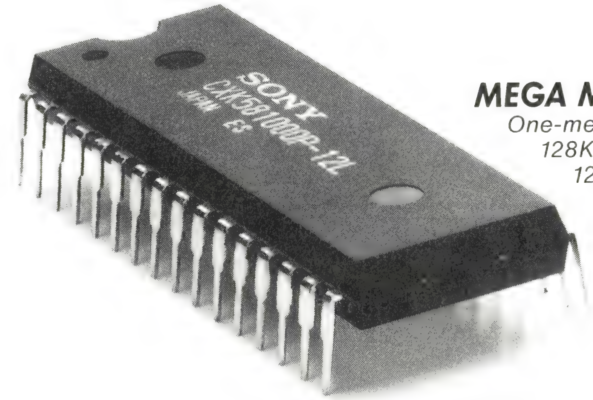
THE EXTREMES.



MEGA MEMORY.

One-meg SRAM line includes
128K x 8 @ 100/120/150 ns,
128K x 8 @ 70/85 ns,
128K x 8 @ 35/45/55 ns.

Ultra-high density.

Sony solves your board-space problems with three new 1-Mbit SRAMs.

Each is based on our 0.8-micron CMOS technology. Configured as 128K x 8 bits. And available in 32-pin DIP and surface-mount plastic packages.

And not only do Sony 1-Mbit SRAMs maximize board space, but process speeds as well.

HIGH-DENSITY SRAMS

MODEL	CONFIG.	SPEED (ns)	PACKAGE
CXK581000P	128K x 8	100/120/150	DIP 600 mil
CXK581000M	128K x 8	100/120/150	SOP 525 mil
CXK581001P	128K x 8	70/85	DIP 600 mil
CXK581001M	128K x 8	70/85	SOP 525 mil
CXK581020SP	128K x 8	35/45/55	DIP 400 mil
CXK581020J	128K x 8	35/45/55	SOJ 400 mil

Nowhere else will you find a greater choice: 100/120/150-ns, 70/85-ns and 35/45/55-ns speed figures.

Sony SRAMS cover the performance spectrum.

Sony offers well over one hundred SRAM solutions, covering the entire performance spectrum.

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CIRCLE NO. 46

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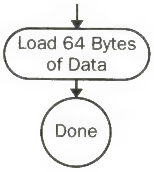
So if you want in-system programmable memory without the hassle remember that the *real flash* is called PEROM.

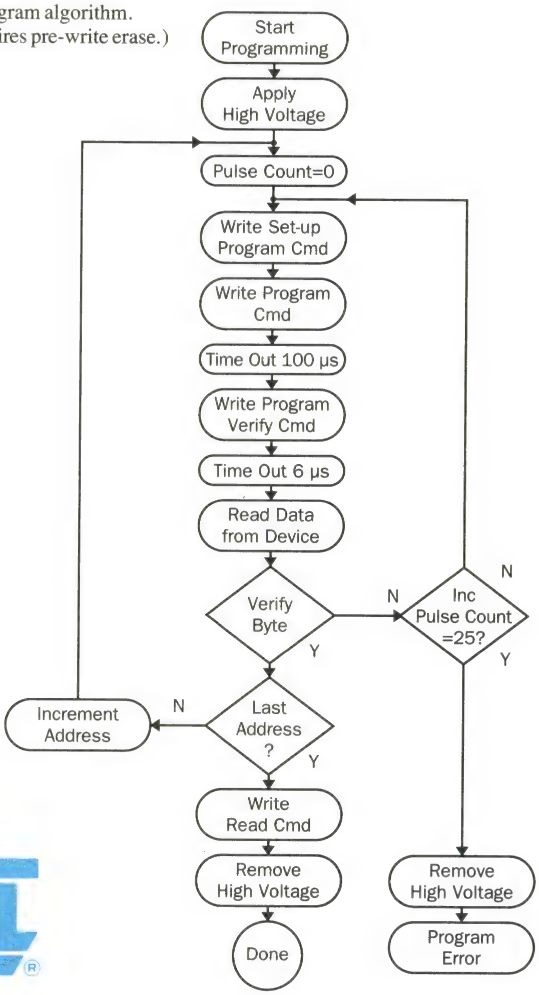
OURS

Reprogram algorithm.
(No erase required.)



THEIRS

Reprogram algorithm.
(Requires pre-write erase.)



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CIRCLE NO. 47

EDITORIAL

Don't call me; I'll call you

Connecticut and Maryland now have laws that outlaw junk FAX—the use of peoples' FAX machines to disseminate unsolicited advertising. I heartily agree with the sentiments that led to the laws, which categorize junk FAX as a type of phone abuse. Perhaps it's time that we look at other twisted-pair privacy invasions.

The night I wrote this editorial I received two unsolicited phone calls at home. One was from a political organization soliciting funds; the other was from a financial consultant who was following a years-old "lead." Evening phone solicitations at home have become more frequent over the last few years. Also, salespeople tend to call between 5:30 and 7:00 pm, when most families are eating dinner. Naturally, salespeople expect you to be home at mealtime—and ripe for the plucking. Today, possession of your phone number is a license to invade your privacy.

As the calls have become more frequent, I have become less than cordial to these callous invaders of my privacy, much to the concern of my seven-year-old daughter. When I returned to putting her to bed after hanging up on the financial consultant, she asked me if working in the evening was against the law. I told her that working late hours was legal, but her question started me thinking. If we're willing to pass laws that prevent unsolicited use of our FAX machines, why aren't we willing to protect our telephone privacy in the same manner? Isn't the privacy of our home life more important than a few feet of FAX paper?

We can ask to have our names removed from junk-mail lists, but anonymous phone solicitors stay safely out of reach at the other end of the phone line. Universal protection from junk phone calls isn't technically possible right now, because we don't usually know the caller's phone number and so we can't register a complaint. Also, if there were penalties for such intrusions, you can bet that the salesperson wouldn't give you his phone number. However, technology is about to change the situation. In some areas of the US, the phone company can furnish you with each caller's phone number before you answer the phone. When all of the nation's phones display the caller's phone number, we might be able to retrieve some of the privacy that we've lost to phone solicitors. This technology opens a new market for electronics, too—units that screen incoming calls before I answer the phone. I can't wait.

Steven H. Leibson

Steven H Leibson
Senior Regional Editor

Jesse H Neal
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1987, 1981 (2), 1978 (2),
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One good idea after another.

CIRCLE NO. 48

TECHNOLOGY UPDATE

THE INDUSTRIAL PC

Harsh conditions affect industrial PC design

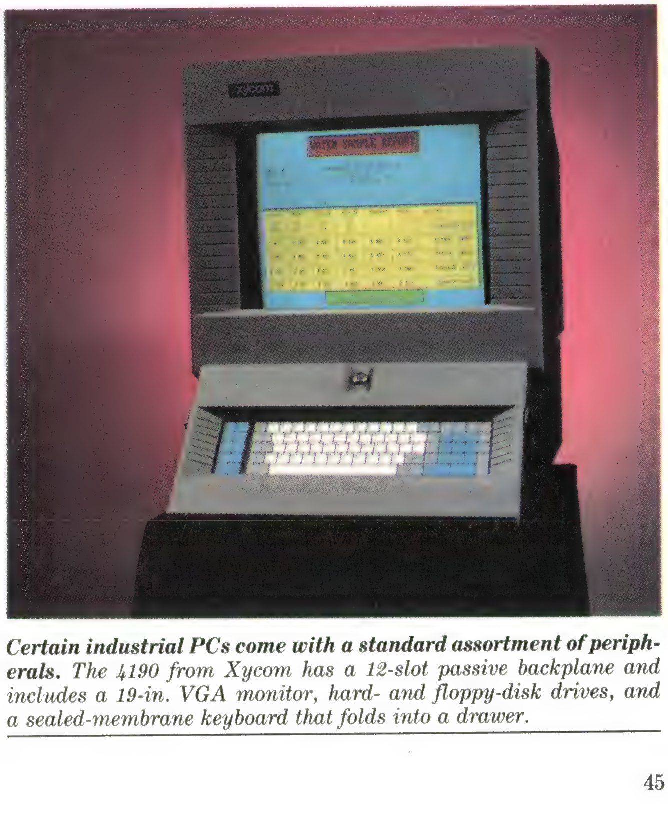
The popularity of the IBM PC makes it desirable for controlling operations on the industrial floor. Accordingly, PC vendors have made considerable modifications to the original PC so that it operates reliably in hostile environments.

John A Gallant,
Associate Editor

Since the advent of the IBM PC in 1981, system developers have created a wide base of applications for this popular computer. The PC's popularity is based on three factors: its low cost, an expanding volume of sophisticated software, and a hardware open architecture that has allowed the development of a wide variety of peripheral boards and devices. You can find this versatile machine in virtually every walk of life, and the industrial process-control and plant-automation markets are no exception. The industrial environment, however, imposes constraints on the PC that usually aren't present in the office environment. These added constraints essentially have spawned a new class of computers—the industrial PC.

The average office PC clone doesn't comply with the certification requirements of the regulatory agencies. For industrial use in the US, however, the PC requires an FCC class A or B license and a UL recommendation. In Canada, it needs CSA approval, and a VDE certification is necessary in West Germany. In addition, the PC often needs shock and vibration protection for the disk drives and pc boards, air filtration to eliminate airborne particles, an extended operating-temperature range, a rack-mounted chassis, and RF and EMI protection.

The industrial PC can take many forms. For example, it can consist of an embedded card cage, such as the STD Bus or VMEbus, which houses a single-board computer running MS DOS—the PC's operating system. Ziatech offers the ZT300, an STD Bus chassis that can house single-board computers with either V20, V50, or 80386SX μPs. The combination of these single-board computers with optional company-supplied peripherals creates an industrial PC operating MS DOS on the STD Bus. Pro-Log also offers STD Bus single-board computers with rugged specifications. Pro-Log's System 2 boards have either a V20, 80286, or 80386SX μP. They operate from 0 to 65°C, have an MTBF of 10 years at 55°C, and can with-



Certain industrial PCs come with a standard assortment of peripherals. *The 4190 from Xycom has a 12-slot passive backplane and includes a 19-in. VGA monitor, hard- and floppy-disk drives, and a sealed-membrane keyboard that folds into a drawer.*

RELIABLE PCs AND SBCs

Service:	Enclosure:	Model:	Maximum Rotating Memory	No. of Plug-In Slots:	Compatible CPUs Available:	Maximum RAM on CPU (MB):	Clock Speed/s (MHz):
Factory, lab, other difficult environments	Industrial Workstation	1448	1 or 2 3.5 inch	9	AT, AT/386 only	16 (AT/386)	To 33
	Free standing, heavy duty benchtop	2003	1 or 2 3.5 inch	10	XT AT AT/386 AT/486	2.56 XT	4.77, 10
Industrial, lab, commercial	Standard rack mount	2001	Up to 3 1/2 height	10		4 AT	6, 10, 12.5, 16 20
	Large capacity rack mount	3014	Up to 5 1/2 height	14			
Office environments	Desktop	4008	Up to 3 1/2 height	8		16 AT/386	16, 20, 25, 33
	Large capacity tower	5014	Up to 10 1/2 height	14		64 AT/486	25, 33

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CIRCLE NO. 49

stand shocks of 40g and vibrations of 5g.

Radix Microsystems offers a PC-compatible module for the embedded-VMEbus market. The EPC-3 comprises an 80386SX single-board computer that has as much as 4M bytes of RAM and a mass-storage module with a 3.5-in., 1.44M-byte floppy-disk drive and a 40M-byte hard-disk drive. The mass-storage module operates from 0 to 55°C and can withstand a 5g shock. The module runs on the company's EPconnect software for the DOS/Windows with Microsoft's Dynamic Data Exchange and the OS/2 operating systems.

Here we'll concentrate mainly on those manufacturers who have made the necessary modifications to the original PC packaging in order to incorporate PC/AT- and PC/XT-style cards in the industrial PC. Many of these manufacturers found it necessary to use a passive backplane. The original PC uses a mother board with the µP, memory, and bus-control circuitry. The mother board has an elaborate wiring harness and is bolted to the chassis. It also contains a variety of expansion slots for third-party pc cards.

Although a mother board is generally an inexpensive approach to computer design, the MTTR of a defective component on the board is longer than the time for replacing a single-board computer in a passive backplane. Essentially, the repair requires complete disassembly of the chassis, including removal of the pc cards and disconnection of the power supply.

Because a short MTTR is crucial for many real-time, industrial process-control systems, a single-board computer that installs into a passive backplane gives the operator the luxury of turning off the system, removing the offending single-board computer, and replacing it when a failure occurs. The MTTR can be reduced to minutes instead of hours for the mother board. The passive backplane also allows more flexibility when configuring the size of the card-cage assembly and chassis to respond to customer needs.

A passive backplane with a plug-in single-board computer *reduces the MTTR and provides flexibility. The Model 2001 from Texas Microsystems Inc can accommodate any combination of 10 plug-in PC/AT- and PC/XT-type cards.*

Industrial PCs are workhorses

Often an industrial PC contains many more plug-in boards than an office PC does. The card cage can contain digital I/O cards for controlling both electromechanical switches and temperature-detection devices; analog I/O cards with A/D converters for data acquisition; counter/timer cards for monitoring the elapsed time between events; waveform-digitizer cards for generating test waveforms; IEE-488 adapters; expanded-memory boards; network-communication cards; motor-controller cards; and solid-state disk-emulator cards for applications in which hard-disk drives can't operate effectively.

The density of pc boards and the necessity for adequate power places a strain on the industrial PC's cooling requirements. The higher temperatures on the factory floor further exasperate the cooling problem. Therefore, manufacturers often include multiple, large-air-volume-rate fans with air filters on the chassis air inlet. The filters are removable and can be replaced or cleaned in minutes. The large fans create a positive-pressure gradient between the air inside the chassis and the air outside it. The positive-pressure gradient protects against airborne particles entering through a crevice in the chassis.

Although most commercial disk drives have integral shock and vibration protection to prevent head crashes, the protection often isn't adequate for industrial use. Therefore, certain manufacturers provide additional protection by mounting the drives on shock-isolated frames within the chassis. This assembly is usually isolated from the rest of the chassis by rubber isolators. Because the isolators are the only contact between the assembly and the chassis, they provide a cushion for shock and vibration.

Another limitation of the original PC bus for industrial applications is the standard card-edge connector. Under vibration or shock, the plug-in boards can easily slip out of the card-edge connector. Many manufacturers remedy this problem by using a hold-down bracket that fits above the plug-in boards; this bracket keeps them from being dislodged. Not all pc cards have the same vertical dimensions, so a good hold-down bracket should have extensions to hold both PC/AT- and the smaller PC/XT-style cards.

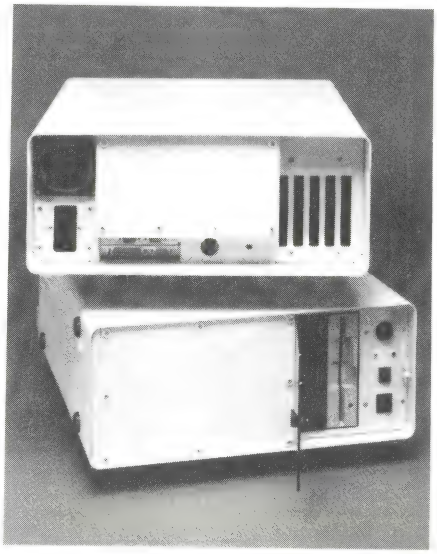
19-in. rack mounts are popular

The industrial floor can also place restrictions on the type of PC enclosure you use. Not all applications can afford the space required for a stand-alone benchtop PC. Space constraints often necessitate a rack- or wall-mounted unit. Industrial PCs generally come in 19-in., rack-mounted versions or benchtop models with provisions for rack or wall mounting. In fact, many manufacturers simply provide card cages that embed into a pre-existing form factor. A bare card cage typically doesn't include power supplies, a wiring harness, or cooling fans.

Many industrial applications dictate the use of equipment with protection against specified environments. The National Electrical Manufacturers Association (NEMA) defines a series of standards for the testing and performance of an enclosure for a particular industrial environment. The most widely used NEMA standards pertaining to nonhazardous environments are the NEMA 4, 4X, and 12 standards. NEMA defines hazardous materials as gases, vapors, combustible dusts, and fibers that are explosive under certain conditions.

The extensive PC-compatible software library is also available on other popular, passive-backplane platforms. *The Radix Microsystems' EPC-3 module operates on the VMEbus using DOS/Windows and supports Microsoft's Dynamic Data Exchange software.*

One of the most important modifications to the original IBM PC for industrial use was rewriting the BIOS. The standard IBM PC BIOS and standard BIOS versions from third-party vendors, such as Phoenix and Award, are inadequate for industrial applications. The standard BIOS includes a Power On Self Test (POST) that aborts booting the computer when the hardware configuration doesn't include a disk controller, a disk drive, a keyboard, and an adapter for the display monitor. Because many industrial applications preclude the use of some of these peripherals, the BIOS must be modified to handle the particular configuration.



The 7×17×19-in. chassis houses a mother board with an 80286 µP *along with one PC/XT-style expansion slot and three PC/AT-style expansion slots. The VIPc industrial PC from Burr-Brown can be mounted in a number of ways in an embedded system.*

Both Phoenix and Award offer options to their standard BIOS to handle different hardware configurations. In addition, many manufacturers have a licensing agreement with the BIOS vendors so that they can perform modifications on the BIOS to suit particular customer demands. You may want to enquire whether an industrial PC vendor has the rights to modify the BIOS code to meet any special needs.

A PromDisk utility program is also necessary for those applications

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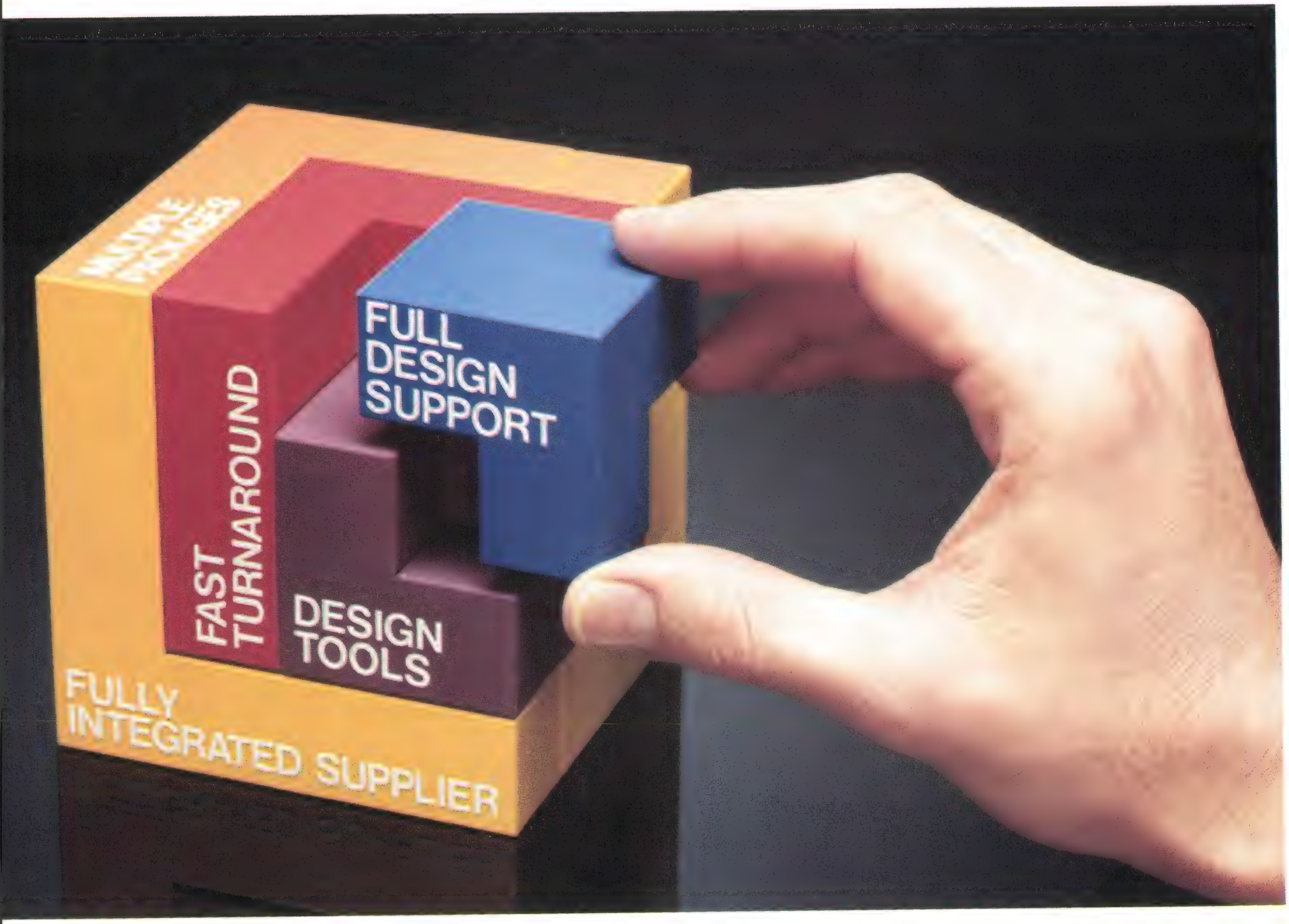

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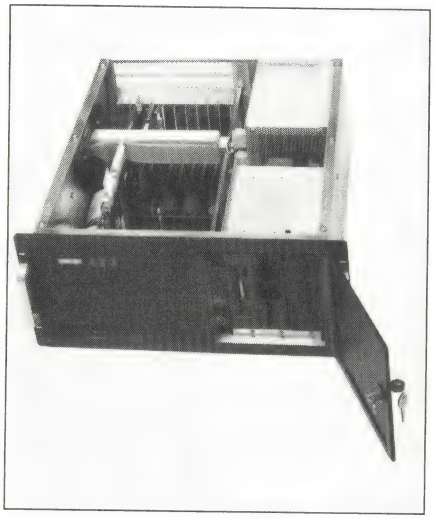
[1] SPICE developed by University of California

that can't operate with a hard-disk drive. To support commercial compilers, the utility permits the placing of DOS into an EPROM. Many high-level-language developers assume that DOS is resident on a disk drive, so they rely on the DOS to handle the housekeeping chores. Thus, many compilers can't produce executable code without a PromDisk utility.

Table 1 is a compilation of the features found in certain commercially available, industrial PC chassis with PC/AT- and PC/XT-style expansion slots. Most of the manufacturers offer chassis with passive backplanes for a low MTTR. Both the Industrial Computer Source and Systems Manufacturing Technology quote an MTTR of 10 minutes for their passive-backplane PCs. However, certain vendors, such as Burr-Brown, Intecolor, and PCQT, offer their products with mother boards. PCQT believes that by offering a product that has high reliability, repairs will rarely be needed. Both the 286-16Z and the 386-25C boast an MTBF of 45,000 hours, which translates to five years of continuous, power-on operation.

Intecolor's 3001 workstation, Lynx Real-Time Systems' IS/386, Daisy Data's PCMate and MiniMate, and Xycom's 4190 are complete industrial PCs that come with hard-disk drives and display monitors. The other products in the **Table** are PC chassis with cooling fans and power supplies. The chassis also have space for mounting disk drives and feature options for a customer-specified monitor. All of the vendors listed in the **Table** use independent laboratories to qualify their environmental specifications. This project is expensive and time consuming because some of the products are new, so certain environmental specifications are still pending. Unless otherwise noted, the prices are only for the chassis that contain fans and power supplies.



Rugged enclosures have many features for harsh environments. *The QPC-7200 from Qualogy has a 10-slot passive backplane, space behind a locked door for two half-height storage devices, a 100-cfm positive-pressure fan, and a welded steel chassis for EMI and RFI protection.*

All of these products are PC compatible, so they operate with either PC DOS or MS DOS. In addition, most vendors offer a variety of single-board computers that can operate with Unix, Xenix, OS/2, QNX, PC MOS, and most of the other operating systems. Industrial Computer Source and American Advantech Corp also offer a library of software-development tools. Both companies offer Labtech Notebook for data-acquisition analysis, Asyst for mathematical functions and graphics, and DADiSP for digital-signal processing.

The Lynx IS/386 runs on the company's LynxOS operating system. The real-time system is compatible with Unix System V.3 and with Berkeley 4.3, and it conforms to the IEEE POSIX 1003.1 standard. It contains a real-time kernel, and the code can be stored in ROM.

Many of the PC-chassis vendors supplement the single-board computer with a variety of optional, accessory plug-in cards and peripherals. For example, Industrial Computer Source offers an array of accessory cards, such as EGA (Enhanced Graphics Adapter) and VGA (Video Graphics Adapter) cards; data-aquisition cards with A/D and D/A converters; digital I/O cards; relay I/O boards; communication boards; counter/timer boards; memory boards; waveform-digitizer cards; stepper-motor boards; and disk-emulator boards. The extensive list of peripherals includes monitors, rack-mounted printers, disk drives, tape-backup systems, and environmentally sealed keyboards.

Of course, you could take your office PC clone and mount it in an environmentally protected enclosure to "industrialize" it. Companies such as Integration Technology Systems offer a wide variety of enclosures specifically for that purpose. The enclosures have shock-mounted hold-down brackets for the PC. They meet the integrity of the NEMA 12 standard and come in desktop, 19-in. rack-mounted, and floor-standing designs. The prices range from $495 for the IP10 desktop model to $1495 for the IS66 floor-standing model. Three cooling options are also available.

Multitasking—key to the future?

What's in the future for the industrial PC? One of the limitations of the original IBM PC and its DOS is the inability to perform multitasking—running concurrent tasks on more than one processor. Although vendors claim that some of their products can perform multitasking, the PC/AT and PC/XT buses aren't designed for this purpose. IBM's Micro Channel and the new EISA bus are designed to overcome this difficulty. It's too

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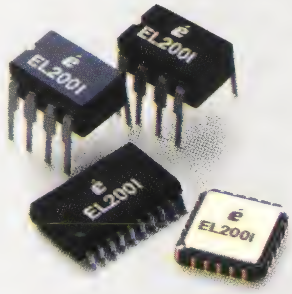

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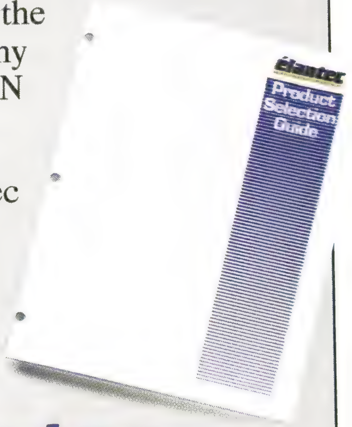

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CIRCLE NO. 51

early to expect industrialized EISA computers, but IBM is committed to exploiting the Micro Channel bus in the industrial marketplace.

IBM offers a variety of industrial Micro Channel computers. The latest model, the GearBox Model 800, has a 25-MHz 80386 with 32k bytes of cache memory; a 120M-byte hard-disk drive; a 1.44M-byte floppy-disk drive; a self-ranging, 300W power supply; redundant cooling fans; and a passive backplane with seven expansion slots. The $22,000 unit has an operational vibration specification of .15g between 10 and 150 Hz and an operational shock specification of 5g.

Although some battle lines are being drawn for the future of the industrial PC, the PC/AT and PC/XT buses currently have a decided cost advantage over the Micro Channel and EISA buses. The original PC bus remains a cost-effective bus structure, and the availability of software for it makes it easy for you to develop software for your applications.

Tables start on pg 54

Article Interest Quotient
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High 515 Medium 516 Low 517

For more information . . .

For more information on the industrial-PC products discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

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CIRCLE NO. 52

Table 1—Representative industrial PCs

Company	Product	Expansion bus	Drive accommodation	Operator Interface	Monitor	Enclosure	Environmental specifications					
							Temperature	Humidity	Vibration		Shock	Altitude
									Operating	Non-operating		
American Advantech	IPC 600	Six PC/AT and two PC/XT slots (passive)	Two half-height drives	Rear-panel keyboard port	Not available	19-in. rack mount	0 to 50°C (operating) 0 to 70°C (nonoperating)	10 to 85% non-condensing at 430°C	.56g 17 to 500 Hz	1g 17 to 500 Hz	NS	10,000 ft
Burr-Brown	VIPc	One PC/XT and three PC/AT slots (motherboard)	Two floppy-disk drives and two hard-disk drives (all half height)	Front- or rear-panel keyboard ports	13-in. EGA rack or table mount (optional)	Rack, desk, or wall mount	0 to 50°C (operating)	NS	NS	NS	NS	NS
Diversified Technology	CHI 625	Three PC/XT and seven PC/AT slots (passive)	One floppy-disk drive and one hard-disk drive (both half height)	D subminiature connectors	Available on customer demand	Desktop & wall mount	0 to 60°C (operating)	0 to 95% (non-condensing)	NS	NS	NS	NS
	CRM/714	14 PC/AT slots (passive)	One hard-disk drive and two floppy-disk drives (all half height)	D subminiature connectors	Available on customer demand	19-in. rack mount	0 to 60°C (operating)	0 to 95% (non-condensing)	NS	NS	NS	NS
	CHI 626	Seven PC/AT and three PC/XT slots (passive)	Two half-height disk drives	D subminiature connectors	Available on customer demand	Desktop & wall mount	0 to 60°C (operating)	0 to 95% non-condensing	NS	NS	NS	NS
	CRM/710	Seven PC/AT and three PC/XT slots (passive)	Three half-height floppy disk drives and a 3.5-in. hard-disk drive	D subminiature connectors	Available on customer demand	14-in. rack mount	0 to 60°C (operating)	0 to 95% (non-condensing)	NS	NS	NS	NS
Daisy Data	PC Mate	Six PC/AT and four PC/XT slots (passive)	20M-byte internal hard disk, port for remote floppy-disk drive	Front-panel keyboard port	14 or 19-in. EGA VGA display (standard)	NEMA 4, 4X, or 12. benchtop	0 to 35°C (operating) 0 to 70°C (nonoperating)	10 to 100% (condensing)	.15g 10 to 500 Hz	NS	10g (operating)	NS
	Mini-mate	One PC/XT and two PC/AT slots (passive)	1.4M-byte, 3.5-in. floppy-disk drive; 40M-byte hard-disk drive	60-key data function pad & shortened QWERTY keyboard	Flat-panel LCD; 80 char/line 24 lines (standard)	NEMA 4X benchtop	−10 to +40°C (operating) −40 to +60°C (nonoperating)	10 to 80% (non-condensing) 10 to 100% (condensing)	.15g 10 to 500 Hz	.30g 5 to 1000 Hz	5g (operating)	NS
I-Bus	5100 Series	20 PC/AT slots (passive)	None	Keyboard port (front)	NS	Benchtop or rack mount	0 to 50°C (operating) −10 to +70°C (nonoperating)	0 to 90% (non-condensing)	NS	NS	NS	NS
	4481 & 4650 Series	Four PC/AT slots (4481 passive); six PC/AT slots (4650 passive)	None (4481); two half-height disk drives (4650)	None (4481) keyboard port (front) (4650)	NS	Benchtop (4481) benchtop or rack mount (4650)	0 to 50°C (operating) −10 to +70°C (nonoperating)	NS	NS	NS	NS	NS
	4800 Series	12 PC/AT slots (passive)	Four half-height disk drives	Keyboard (front)	NS	Benchtop or rack mount	0 to 50°C (operating) −10 to +70°C (nonoperating)	NS	NS	NS	NS	NS
Industrial Computer Source	7500/7600	Six PC/AT and four PC/XT (passive or motherboard)	Two half-height disk drives	Keyboard ports (front & rear)	EGA & VGA monitors (optional)	14-in. rack mount (7500) benchtop (7600)	0 to 50°C (operating) −5 to 75°C (nonoperating)	10 to 90% non-condensing	18g 60 to 500 Hz	NS	NS	10,000 ft
	8531/8532	Five PC/AT and five PC/XT slots (passive)	Two half-height disk drives and one full-height disk drive	Front & rear keyboard ports	12-in. VGA multi synchronous monitor (standard)	14-in. rack mount or benchtop	0 to 40°C (operating) −5 to 75°C (nonoperating)	10 to 90% non-condensing	1g 60 to 500 Hz	NS	NS	10,000 ft
	Node-D-ATC	Six PC/XT or three PC/AT and three PC/XT slots (passive)	One half-height disk drive	Front-panel keyboard port	Via a video adapter card (optional)	Compact package for installation in a NEMA chassis	0 to 55°C (operating) −5 to 75°C (nonoperating)	5 to 95% non-condensing	1g 60 to 500 Hz	NS	NS	10,000 ft
	8600-RE Work-station	Nine PC/AT slots (passive)	Two half-height disk drives	28-key data keypad; 20-key function keypad	14-in. EGA monitor	NEMA 4 19-in. rack and panel mount	NS	NS	NS	NS	NS	NS
Intecolor	3001 Work-stations	Four PC/AT slots (on mother-board)	3.5-in. 1.44M-byte floppy-disk drive, 40M-byte hard-disk drive	PC/AT-type keyboard NEMA 1 (standard)	20-in SVGA monitor (standard)	14-in. rack mount & bench top (NEMA 2)	10 to 42°C (operating) −30 to +60°C (nonoperating)	8 to 80% non-condensing	0.5g 5 to 2000 Hz	1.5g 5 to 2000 Hz	10g (operating) 30g (in transit)	10,000 ft
Lynx Real-Time Systems	IS/386	13 PC/AT slots (passive)	1.2M-byte floppy-disk drive; SCSI port for 40M-byte to 660M-byte hard-disk drive	2 RS232C front-panel keyboard ports	VGA color multisync (optional)	14-in. rack mount, steel chassis	NS	NS	NS	NS	NS	NS

Key: EGA=Enhanced Graphics Adapter; FM=Factory Mutual; NS=Not Specified; VGA=Video Graphics Adapter

Dimensions and weight	Available single-board computers			Power supply 110/220 V ac	Cooling capacity	Optional accessory cards	Certi-fication	BIOS	Price	Comments
	CPUs	Maximum RAM on single-board computer (byte)	Clock speeds (MHz)							
7×19×22 in. 23 lbs	80286 80386	8M(286) 16M(386)	8,12.5(286) 20(386)	200W 47 to 63 Hz	2(NS) cfm fans	I/O cards, IEEE-488, autoboot card, video card, disk controller	FCC Class A; UL	Standard, Award	$1450 (chassis)	Includes pc-board hold brackets; shock-mounted disk drives; 1-piece chassis construction.
7×17×19 in. 30 lbs	80286 (on mother-board)	4M	6.25,12.5	110W 47 to 440 Hz	30-cfm fan	Signal conditioners, data-acquisition cards	CSA; VDE; FCC Class A	Standard Phoenix (without keyboard)	$3995 to $6445	Card cage handles termination panels or VMEbus boards, EMI-shielded card cage. Can be mounted in many ways.
6.0×13.6×14.25 in. 10 lbs	8088 80286 80386 80386SX	256k(88) 4M(286) 8M(386) 2M(386SX)	4.77,7,10(88) 8,10,16,20(286) 16,20,25(386) 16(386SX)	80W or 150W (optional) 47 to 440 Hz	NS	I/O cards, communication card, video card, SCSI card, disk controller	Pending	Phoenix, Award, Faraday, Paradise	$460 (special order)	
7×19×21 in. 30 lbs	8088 80286 80386 80386SX	256k(88) 4M(286) 8M(386) 2M(386SX)	10,12,16, 24 MHz	150W, 250W, 350W, 47 to 440 Hz	NS	I/O cards, communication card, video card, SCSI card, disk controller	VDE, UL, FCC Class A	Phoenix, Award, Faraday, Paradise	$1318 (250W power supply)	
7×14×16.25 in. 12 lbs	8088 80286 80386 80386SX	256k(88) 4M(286) 8M(386) 2M(386SX)	NS	150W 47 to 440 Hz	96-cfm fan	I/O cards, com. card, video card, SCSI card, disk controller	Pending	Phoenix, Award, Faraday, Paradise	$770 (chassis)	
7×14.1×16.2 in. 25 lbs	8088 80286 80386 80386SX	256k(88) 4M(286) 8M(386) 2M(386SX)	4.77,7,10(88) 8,10,16,20(286) 16,20,25(386) 16(386SX)	200W 47 to 440 Hz	180-cfm fans	I/O cards, com. card, video card, SCSI card, disk controller	Pending	Phoenix, Award, Faraday, Paradise	$870 (chassis)	
26×20.75×23.0 in. for 19-in. model 156 lbs	80286 80386	16M	10,12.5,16(286) 16,20(386)	150W 47 to 63 Hz	Fan within completely sealed chassis	None	FCC Class A FM(4X)	Standard Phoenix and Award	$7000 (10-MHz 286 VGA card 20M-byte hard disk keyboard	$12,000 for same model with NEMA 4X enclosure that meets FM requirements. Type 316 stainless steel.
17.0×14.375×6.5 in. 20 lbs	80C286	4M	12,16	47 to 63 Hz 50W (UPS optional)	Fan within completely sealed chassis	None	Pending	Standard Phoenix and Award	$4500 to $7000	Type 316 stainless steel.
7×19×21 in. (rack mount)	80286 80386 8088	4M(286) 8M(386) 1M(88)	8,10,12,16(286) 16,25(386) 10(88)	200W, 270W, 325W 47-63 Hz	Three 26-cfm fans	None	UL,CSA certified FCC Class A	Modified Award	$1335 (20-slot, 200W power-supply chassis)	Backplane can be segmented to provide two or more independent systems. Optional connector panel.
2.3×14.5×15.5 in.	80286 80386 8088	4M(286) 8M(386) 1M(88)	8,10,12,16(286) 16,25(386) 10(88)	135W 47 to 63 Hz	13-cfm fans	None	NS	Modified Award	$695 (4481) $695 (4650)	4481 is a low-profile unit with the footprint of a monitor.
7×12×20 in. (rack mount)	80286 80386 8088	4M(286) 8M(386) 1M(88)	8,10,12,16(286) 16,25(386) 10(88)	200W, 270W, 325W 47-63 Hz	82-cfm fan	none	UL,CSA certified FCC Class A	Modified Award	$1395 (12-slot, 200W power-supply chassis)	Backplane can be segmented to provide two or more independent systems. Disk drive features locked doors.
7×17×24 in. (7500) 50 to 70 lbs	8088 80286 80386	640k(88) 4M(286) 16M(386)	4,77(88) 12,16(286) 16,20,25(386)	315W 47 to 440 Hz	2 120 cfm fans(chassis) 1 24-cfm fan (power supply)	Video adapters, active motherboards, I/O cards, IEEE-488 card, RAM disk, motion control	FCC Class A	Company's ROM BIOS	$1495 (chassis)	MTBF is greater than 150,000 hours, MTTR=10 minutes, pc-board hold brackets, steel chassis, shock-mount drive cage.
14×19×24 in. (rack mount) 50 to 70 lbs	8088 80286 80386	640k(88) 4M(286) 16M(386)	4,77(88) 12,16(286) 16,20,25(386)	250W 47 to 63 Hz	Two 120-cfm fans (8532)	Video adapters, active motherboards, I/O cards, IEEE-488 card, RAM disk, motion control	FCC Class A	Company's ROM BIOS	$3995 (chassis and monitor)	Aluminum chassis, shock-mount drive cage, Lexan CRT shield.
8.5×6.0×16.75 in. 12 lbs	8088 80286 80386	640k(88) 4M(286) 16M(386)	4,77(88) 12,16(296) 16,20,25(396)	65W 47 to 440 Hz	24-cfm fan	Video adapters, active motherboards, I/O cards, IEEE-488 card, RAM disk, motion control	FCC Class A	Company's ROM BIOS	$795 (XT/AT chassis)	MTBF is greater than 150,000 hours, MTTR=10 minutes, includes speaker amplifier.
NS	8088 80286 80386	640k(88) 4M(286) 16M(386)	4,77(88) 12,16(286) 16,20,25(386)	NS	NS	Video adapters, active motherboards, I/O cards, IEEE-488 card, RAM disk, motion control	NS	Company's ROM BIOS	$4595 (chassis and monitor)	Flip-out card cage for easy pc-board access, disk-drive door locks.
19.8×19.1×23.1 in. 100 lbs (NEMA 2)	80386SX (on mother-board)	4M	16	170W 47 to 63 Hz	40-cfm fan	Solid-state RAM disk, memory card	FCC Class A UL 478	Standard Phoenix BIOS in Shadow RAM	$8995 (system)	Autoranging power supply, disk-drive door locks, 2-mil copper traces throughout display electronics to reduce oxidation.
7×19×20.5 in. 50 lbs	80386 80386SX	8M(386) 8M(386SX)	25(386) 16(386SX)	220W 47 to 63 Hz	Three fans (NS capacity)	SCSI controller, battery-backed memory board	Pending	Not necessary for LynxOS	$6995 (386SX) $11,995 (386) (with 40M-byte disk drive	Shock mounts for disk drives, RF/EMI resistant, pc-board hold brackets. Disk-drive locked doors.

Table continued

Table 1—Representative industrial PCs (continued)

							Environmental specifications					
									Vibration			
Company	Product	Expansion bus	Drive accommodation	Operator interface	Monitor	Enclosure	Temperature	Humidity	Operating	Non-operating	Shock	Altitude
PCQT	286-16Z	Five PC/AT and three PC/XT (on motherboard)	SCSI port; four half-height drives	Front and rear keyboard ports (two serial, one parallel)	Available on customer demand	Benchtop, 19-in. rack mount, or tower	5 to 40°C (operating) −40 to +70°C (nonoperating)	To 93% non-condensing	1g 10 to 500 Hz (with disks)	4g 10 to 500 Hz (with disks)	5g (operating) (in 20g transit)	NS
	386-25C	One PC/XT and five PC/AT slots (on motherboard)	SCSI port, four half-height drives	Front and rear keyboard ports (two serial, one parallel)	Available on customer demand	Benchtop, 19-in. rack mount, or tower	5 to 40°C (operating) −40 to +70°C (nonoperating)	To 93% (non-condensing)	1g 10 to 500 Hz (with disks)	4g 10 to 500 Hz (with disks)	5g (operating) 20g (transit)	NS
Qualogy	QPC-7100	12 PC/AT or six PC/AT and six PC/XT slots (passive)	Two half-height disk drives	Rear-panel keyboard port	Rack-mounting kit for monitor (optional)	19-in. rack mount	0 to 50°C (operating) −25 to 80°C (nonoperating)	0 to 95% (non-condensing)	NS	NS	NS	NS
	QPC-7200	10 PC/AT and 10 PC/XT slots (passive)	Two half-height disk drives	Rear-panel keyboard port	Rack-mounting kit for monitor (optional)	19-in. rack mount	0 to 50°C (operating) −25 to 80°C (nonoperating)	0 to 95% (non-condensing)	NS	NS	NS	NS
	QPC-5303	Five PC/AT and five PC/XT slots (passive)	Two half-height disk drives	Rear-panel keyboard port	Rack-mounting kit for monitor (optional)	Benchtop	0 to 50°C (operating) −25 to 80°C (nonoperating)	0 to 95% (non-condensing)	NS	NS	NS	NS
Systems Manufacturing Technology	WM-2100B & WM-2200B	Seven PC/AT slots (passive)	Four half-height disk drives	Keyboard port. 16-key keypad (optional)	9 in. monochrome (2100) (standard) 9 in. EGA (2200) (standard)	NEMA 12 rack mount	0 to 55°C (operating) −20 to 70°C (nonoperating)	0 to 95% (non-condensing)	NS	NS	2g (operating) 50g (in transit)	NS
	RM 5200	12 PC/AT slots (passive)	Four half-height disk drives	150-ft keyboard-extender cable (optional)	14-in. multisynchronous rack mount (optional)	NEMA 12 rack mount	0 to 55°C (operating) −20 to +70°C (nonoperating)	0 to 95% (non-condensing)	NS	NS	2g (operating) 5g (in transit)	NS
Texas Microsystems	1448	9 PC/AT slots (passive) (with options)	Two half-height disk drives	28-key data and a 20-key function pad	14-in. multisynchronous EGA; VGA (standard)	19-in. rack- or panel-mount NEMA 4	0 to 55°C (operating) −20 to +60°C (nonoperating)	10 to 80% (non-condensing)	0.25g 20 to 200 Hz	0.2g 20 to 200 Hz	0.5g (operating) 10g (in transit)	15,000 ft
	2003	10 PC/AT slots (passive, with options)	Two half-height disk drives	Front- & back-panel keyboard ports	Optional EGA, VGA, monochrome NEMA 12	Benchtop	0 to 55°C (operating)	To 95% (non-condensing)	1.5g 5 to 100 Hz	5g 5 to 100 Hz	10g (operating) 40g (in transit)	15,000 ft
	3014	12 PC/AT and two PC/XT slots (passive, with options)	Five half-height disk drives	Front- and back-panel keyboard ports	Optional EGA, VGA, monochrome NEMA 12	19-in. rack mount	0 to 55°C (operating)	To 95% (non-condensing)	0.25g 5 to 100 Hz	1g 5 to 100 Hz	1g (operating)	15,000 ft
	2001	10 PC/AT slots (passive, with options)	Three half-height disk drives	Front- and back-panel keyboard ports	EGA, VGA, monochrome NEMA 12 (optional)	NS 19-in rack mount	0 to 55°C (operating)	To 95% (non-condensing)	1.5g 5 to 100 Hz	5g 5 to 100 Hz	10g (operating) 40g (in transit)	15,000 ft
Xycom	4190	12 PC/AT slots (passive)	1.4M-byte 3.5-in. floppy-disk drive 20M-byte hard-disk drive	Standard folding keyboard or 44-key data & function membrane	19-in. VGA color monitor (standard)	Yoke-pedestal or desktop NEMA 4/ NEMA 12	0 to 50°C (operating) −40 to +60°C (nonoperating)	10 to 80% (non-condensing)	1g 5 to 2000 Hz	2.5g 5 to 2000 Hz	15g (operating) 30g (in transit)	10,000 ft
	4140	6 PC/AT, 9 PC/XT slots (passive)	Three half-height disk drives; 40M-byte hard-disk drive	Optional sealed-membrane keyboard	Optional 14-in. VGA, EGA, NEMA 4/ NEMA 12	19-in. rack mount	0 to 50°C (operating) −40 to +60°C (nonoperating)	10 to 85% (non-condensing)	NS	NS	NS	10,000 ft
	4130	3 PC/AT and 3 PC/XT slots (passive)	None	Optional sealed-membrane keyboard	Not Available	Compact enclosure for NEMA cabinet	0 to 50°C (operating) −40 to +60°C (nonoperating)	10 to 85% (non-condensing)	NS	NS	NS	10,000 ft
	4150/ 4160	1 PC/XT and 4 PC/AT slots (passive)	Two half-height disk drives	101-key membrane keyboard	12-in. EGA (4150) (standard) 12-in. monochrome (4160) (standard)	19-in. rack or panel mount NEMA 4/12	0 to 50°C (operating) −40 to +60°C (nonoperating)	10 to 80% (non-condensing)	1g 5 to 2000 Hz	2.5g 5 to 2000 Hz	15g (operating) 30g (in transit)	10,000 ft

Key: EGA=Enhanced Graphics Adapter; FM=Factory Mutual; NS=Not Specified; VGA=Video Graphics Adapter

Dimensions and weight	Available single-board computers			Power supply 110/220 V ac	Cooling capacity	Optional accessory cards	Certi-fication	BIOS	Price	Comments
	CPUs	Maximum RAM on single-board computer (byte)	Clock speeds (MHz)							
7×17.4× 22.8 in. 46 lbs	80286 (on mother-board)	8M	16	175W 47 to 440 Hz (UPS)	Two fans dissipate heat thru a closed aluminum chassis	I/O cards diagnostic board	UL1950 CSA 22.2 VDE FCC Class A	Modified Phoenix BIOS	$2995 (without disk)	MTBF=45,000 hours (five continuous power-on years), completely sealed chassis, 30-minute battery backup, pc-board hold brackets.
7×17.4× 22.8 in. 46 lbs	80386 (on mother-board)	16M	25	125W 47 to 440 Hz (UPS)	Two fans dissipate heat thru a closed aluminum chassis	Memory card	UL 1950 CSA 22.2 VDE FCC Class A	Modified Phoenix BIOS	$5395 (without disk)	MTBF=45,000 hours (five continuous power-on years), completely sealed chassis, 30-minute battery backup, pc-board hold brackets, 32-bit memory expansion slot.
8.75×19.0× 24.0 in. 49 lbs	80286 80386	4M(286) 8M(386)	8,10,12.5,16 (286) 16,20,25(386)	200W 47 to 63 Hz	40-cfm fan	SCSI controller hard-disk emulator, I/O cards, video adapter	FCC Class A	Award & AMI for 80286, Quantel for 80386	$1495 (chassis)	Stainless-steel chassis, disk-drive door locks.
8.75×19.0× 17.0 in. 38 lbs	80286 80386	4M(286) 8M(386)	8,10,12.5,16 (286) 16,20,25(386)	200W 47 to 63 Hz	100-cfm fan	SCSI controller, hard-disk emulator, I/O cards	FCC Class A	Award and AMI for 80286, Quantel for 80386	$1295 (chassis)	Stainless-steel chassis, disk-drive door locks.
6.75×14.25× 18.25 in. 20 lbs	80286 80386	4M(286) 8M(386)	8,10,12.5,16 (286) 16,20,25(386)	200W 47 to 63 Hz	70-cfm fan	SCSI controller, hard-disk emulator, I/O cards	FCC Class A	Award and AMI for 80286, Quantel for 80386	$925 (chassis)	Aluminum chassis, disk-drive door locks.
10.5×19.0× 18.5 in. 38 lbs (2100) 45 lbs (2200)	80286 80386	8M(286) 16M(386)	16,20(286) 20,25(386)	250W 47 to 440 Hz	NS	8M-byte daughter board, I/O cards, video adapter, disk controller	NS	Modified Phoenix	$1995 (2100) $3195 (2200)	Shock mounts for disk drives, MTTR=10 minutes, pc-board hold brackets.
7×17×18.5 in. 25 lbs	80286 80386	8M(286) 16M(386)	16,20(286) 20,25(386)	250W 47 to 440 Hz	NS	8M-byte daughter board, I/O cards, video adapter, disk controller	NS	Modified Phoenix	$1350 (chassis)	Shock mounts for disk drives, MTTR=10 minutes, pc-board hold brackets.
13.97×19.0× 21.9 in. 65 lbs	8088 80286 80386	2.5M(88) 4M(286) 16M(386)	4.77,10(88) 6,10,12.5,16,20 (286) 16,20,25(386)	150W 47 to 63 Hz	100-cfm fan	I/O board, daughter boards, disk control, video board	FCC Class A	Modified Phoenix	$7550 (20-MHz 386; 20M-byte hard-disk drive EGA video 1.44 M-byte floppy disk drive)	Stainless-steel chassis, keyboard DIN connectors on front & rear panels, pc-board hold brackets. 1-year service contract.
7.1×12.4× 14.5 in. 35 lbs	8088 80286 80386	2.5M(88) 4M(286) 16M(386)	4.77,10(88) 6,10,12.5,16,20 (286) 16,20,25(386)	150W 47 to 440 Hz	30-cfm fan	I/O board, daughter boards, disk control, video board	FCC Class A	Modified Phoenix	$3900	Shock mounts for disk drives, pc-board hold brackets, stainless-steel case, speaker, 1-year service contract.
7.0×19.0× 22.2 in. 45 lbs	8088 80286 80386	2.5M(88) 4M(286) 16M(386)	4.77,10(88) 6,10,12.5,16,20 (286) 16,20,25(386)	225W 47 to 63 Hz	Two 110-cfm fans	I/O board, daughter boards, disk control, video board	FCC Class A	Modified Phoenix	$6175 (20-MHz 386, 40M-byte hard-disk drive 1.2M-byte floppy-disk drive EGA video)	PC-board hold brackets, floppy-disk-drive door lock, speaker, stainless-steel chassis, 1-year service contract.
7.0×17.3× 20.1 in. 55 lbs	8088 80286 80386	2.5M(88) 4M(286) 16M(386)	4.77,10(88) 6,10,12.5,16,20 (286) 16,20,25(386)	220W 47 to 63 Hz	110-cfm fan	I/O board, daughter boards, disk control, video board	FCC Class A	Modified Phoenix	$4540 (12.5-MHz 286) 40M-byte hard disk, 12M-byte floppy disk, EGA video	PC-board hold brackets, floppy-disk-drive door lock, speaker, stainless-steel chassis, 1-year service contract.
NS	80286 80386	4M	12,16,20(286) 16,20,25(386)	NS	NS	VMEbus adapter, video adapter, disk controller, bubble memories	NS	Modified Phoenix	$12,750 (system)	Lexan CRT shield; operates with genesis, multiview, and on spec software packages
7×19×23 in.	80286 80386	4M	12,16,20(286) 16,20,25(386)	250W 47 to 63 Hz	NS	VMEbus adapter, video adapter, disk controller, bubble memories	NS	Modified Phoenix	$1850 (chassis)	Stainless-steel enclosure.
6×9×15.75 in.	80286 80386	4M	12,16,20(286) 16,20,25(386)	65W 47 to 63 Hz	24-cfm fan	VMEbus adapter, video adapter, disk controller, bubble memories	NS	Modified Phoenix	$950 (chassis)	Stainless-steel enclosure.
12.2×19.0× 16.25 in.	80286 80386	4M	12,16,20(286) 16,20,25(386)	175W 47 to 63 Hz	NS	VMEbus adapter, video adapter, disk controller, bubble memories	DEC's PCSA version 2 (4150)	Modified Phoenix	$4680 (4150) $3880 (4160)	Lexan CRT shield

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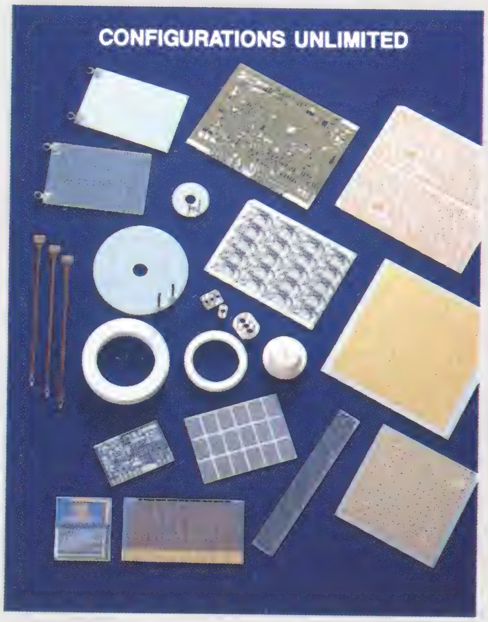
GENERAL CAPABILITIES

	ITEM	SPECIFICATIONS		CONDITIONS
CONDUCTOR	CONDUCTOR RESISTANCE	AgPd . . . . 15-50mΩ/☐ AgPt . . . . 2-4mΩ/☐ Au . . . . 2-4mΩ/☐		—
	ADHESION	≥2.5 KGS — INITIALLY		0.6 COPPER WIRE COVERED WITH SN 2MM ☐ PAD
	SOLDER LEACH RESISTANCE	≥2.0 KGS AFTER AGING (@150°C, 48 HRS.)		62 SN/Pd/2 Ag SOLDER
	ITEM	STANDARD	MAX. AVAIL.	CONDITIONS
RESISTOR	RESISTOR VALUE	10Ω-2MΩ	20mΩ-20MΩ	—
	TCR	±250 PPM /°C	±100 PPM/°C	—
	TRACKING TCR	±100 PPM/°C	±10 PPM/°C	—
	LOAD WATTAGE	150mW/MM²	—	—
	RESISTOR TOLERANCE	> ±1.0%	+0.3%	—
	STABILITY: TEMPERATURE	≤ ±1.5%	—	430°C, 5 MIN.
	HUMIDITY	≤ ±2.0%	—	60°C, 95%
	HEAT CYCLE	≤ ±2.0%	—	125°C↔−40°C (10 CYCLES)
	HIGH TEMP. STORAGE	≤ ±1.5%	—	125°C, 1000 HRS.
[illegible]	INSULATION RESISTANCE	≥100MΩ	—	—



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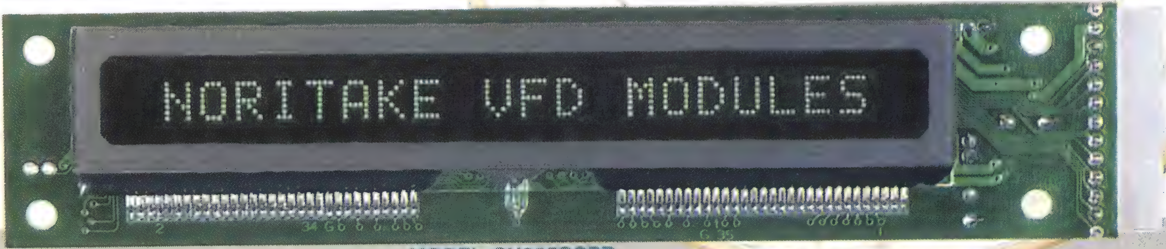

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5 × 7 DOT MATRIX	CU165SCPB-S	1 × 16	5.0	S/P		
	CU169SCPB-L	1 × 16	9.0	P	x	
	CU205SCPB-S	1 × 20	5.0	S/P		
	CU209SCPB-L	1 × 20	9.2	P	x	
	CU2015SCPB-L	1 × 20	15.1	P	x	
5 × 7 DOT MATRIX PLUS CURSOR	CU406SCPB-S	1 × 40	5.0	P	x	
	CU20026SCPB-S	2 × 20	5.1	P	x	x
	CU40026SCPB-S	2 × 40	5.0	P	x	x
	CU40046MCPB-S	4 × 40	5.0	S/P	x	x
	CU40066MCPB-S	6 × 40	5.0	S/P	x	x
	CU40086MCPB-S	8 × 40	5.0	P	x	x

*OPTIONAL

DOT MATRIX DISPLAY MODULES

DOT MATRIX FORMAT (DOTS/LINE × NO. OF LINES)	MODEL NUMBER	NO. OF LINES AND CHARACTERS/LINE (5x7 DOT CONFIGURATION)	GRAPHICS CAPABILITY
192 × 16 (3072 DOTS TOTAL)	GU192X16	2 × 32	YES
256 × 16 (4096 DOTS TOTAL)	GU256X16	2 × 42	YES
256 × 64 (16,384 DOTS TOTAL)	GU256X64	8 × 42	YES

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CIRCLE NO. 53

High-bandwidth DSOs push beyond 20 GHz

Two advanced, general-purpose oscilloscopes offer bandwidths above 20 GHz. Their important architectural differences require you to choose between them carefully.

Doug Conner,
Regional Editor

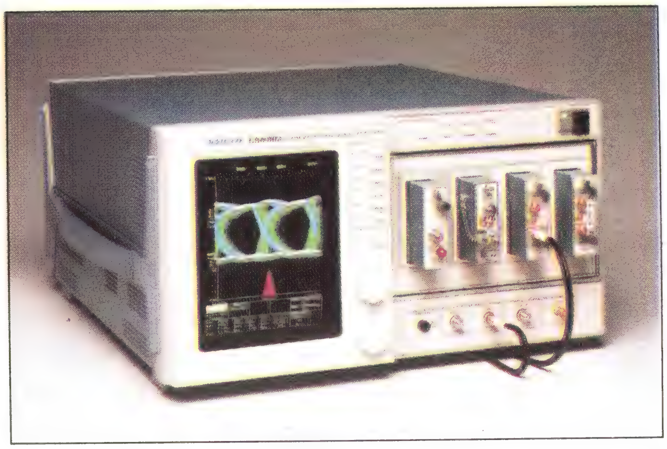
If you need a general-purpose oscilloscope that has a bandwidth higher than 20 GHz, you'll want to consider two advanced digital-storage oscilloscopes (DSOs): Hewlett-Packard's 34-GHz HP54123T and Tektronix's 40-GHz CSA 803. The major design differences between these two DSOs warrant careful consideration and are reflected in how each of the DSOs performs sampling, provides histograms, supports time-domain reflectometry, and performs triggering.

One of the more significant distinctions between the 54123T and the CSA 803 is the method each uses for sampling data. The 54123T uses digital feedback sampling, and the CSA 803 uses analog feedback sampling. Both analog and digital feedback sampling are sequential sampling methods, capturing a single data point with each trigger event. However, the two sampling methods have different consequences on the design of the DSO.

Feedback sampling is useful when you must sample a voltage very rapidly—in a fraction of a picosecond. As in any sampling system, the DSO closes the sampling gate briefly, allowing a charge to build on a sampling capacitor. Because the sampling gate is closed for a very short time, the sampling capacitor doesn't charge to the sampled voltage.

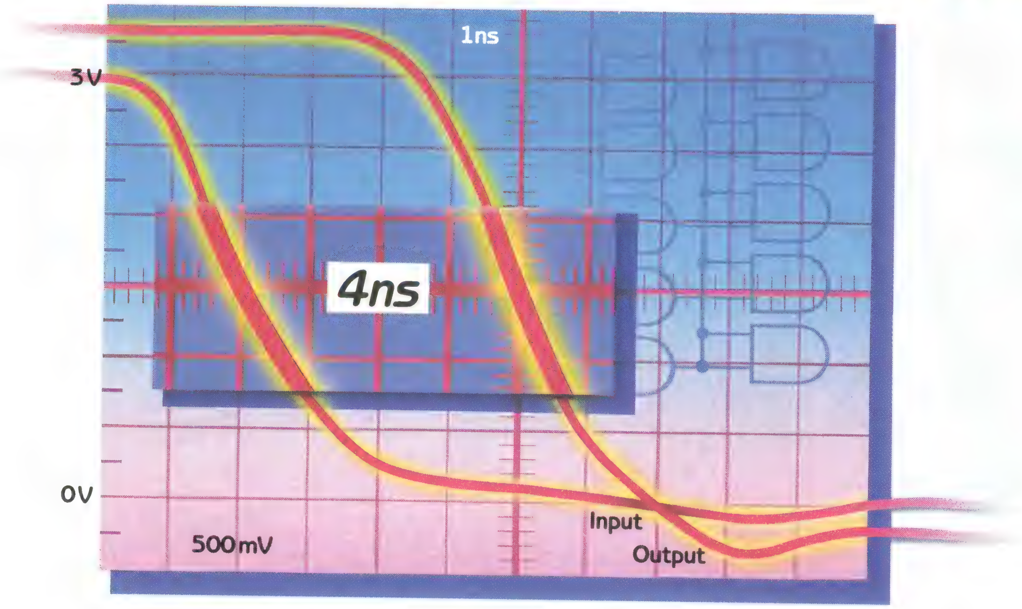
The DSO can correct the voltage on the sampling capacitor if it is given or can derive the sampling efficiency of the system. To arrive at the voltage initially sampled, the DSO multiplies the difference between the voltage on the sampling capacitor and the previously stored value by a correction factor (the loop gain). The circuit feeds back the product of the loop gain and the sampling-capacitor voltage change to the sampling capacitor, precharging it before the next sample. By using feedback sampling with a very short effective time interval—less than a picosecond—between samples, voltage changes captured each time by the sampling capacitor are small (**Ref 1**).

Small voltage changes between each sample let the DSO operate in a narrow voltage region where the loop gain remains constant. Analog feedback sampling uses a constant loop gain, so it must operate in a region where the correct loop gain is constant. Digital feedback sampling accommodates nonlinear



The 40-GHz CSA 803 *from Tektronix provides a display database that allows you to look at multiple time and voltage window histograms without having to reacquire data. The sampling system acquires 200,000 samples/sec.*

FCT-T Logic Fast and Friendly



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CIRCLE NO. 54

High-bandwidth DSOs

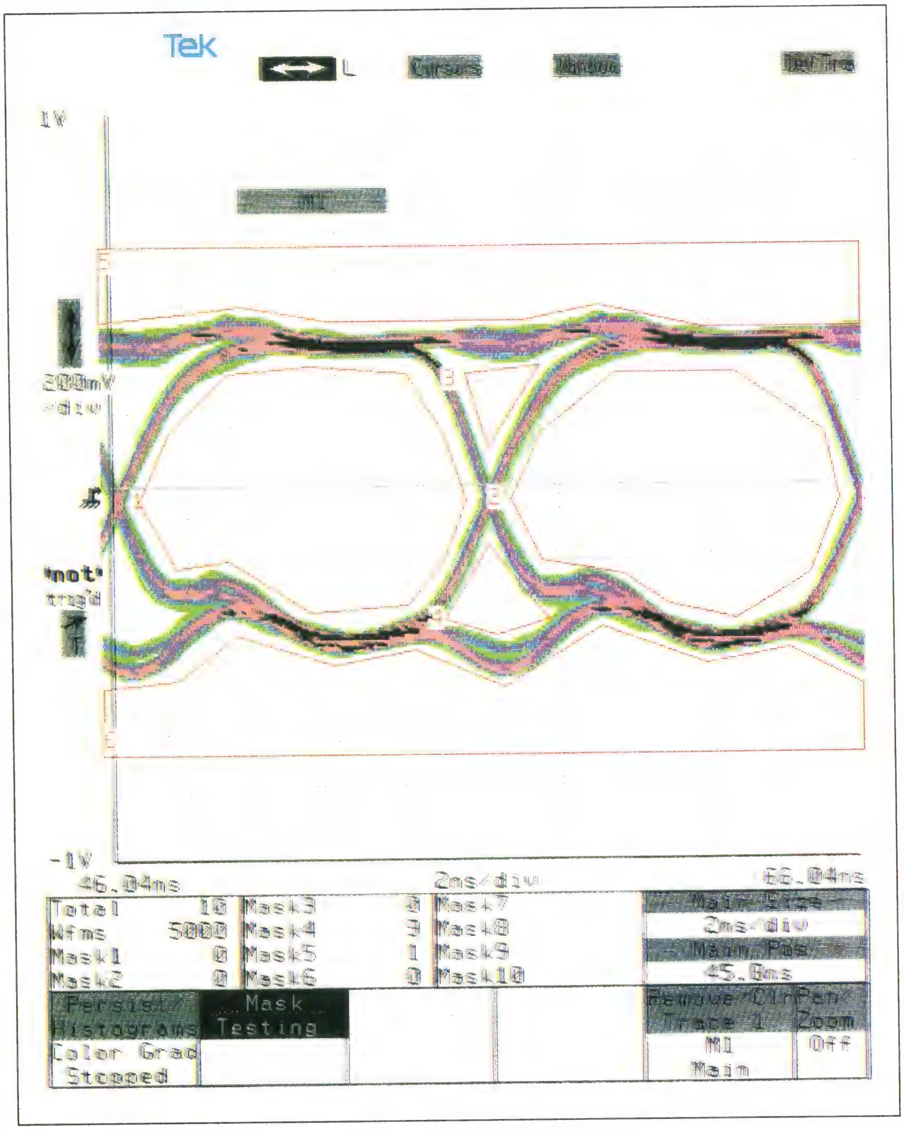
loop gains by using a look-up table.

Small voltage changes between samples normally occur when you're examining an unchanging waveform, even when it has a fast rise time. Unfortunately, these small voltage changes aren't always possible. For example, in eye-pattern displays, each sample taken to form the display can be in a high state, in a low state, or in transition between the two. You can have a high state on one sample, and the sample immediately following it can be in a low state. When you use an analog-feedback-sampling system, you may have difficulty setting a loop gain that's correct for high, low, and transition voltages.

In analog feedback sampling, you must perform a calibration operation to set the loop gain (dot response). To calibrate the DSO properly, you must know what voltages you'll be examining. No universal calibration for the CSA 803 covers all cases. The 54123T's digital-feedback-sampling system also requires a calibration whenever the temperature changes. The 54123T's automatic calibration is, however, usable over the DSO's entire voltage range.

The important difference between the analog- and digital-feedback-sampling systems on these two DSOs is that digital feedback sampling requires no special knowledge on the part of the user. When you use digital feedback sampling, you don't need to calibrate the DSO, and all automatic pulse-parameter measurements are independent.

Digital feedback sampling is user independent, but analog feedback sampling has a faster sampling rate. The CSA 803 has a sampling rate of 200,000 samples/sec—more than 20 times the rate of the 54123T, which features a maximum sampling rate of 10,000 samples/sec (assuming trigger events are present).



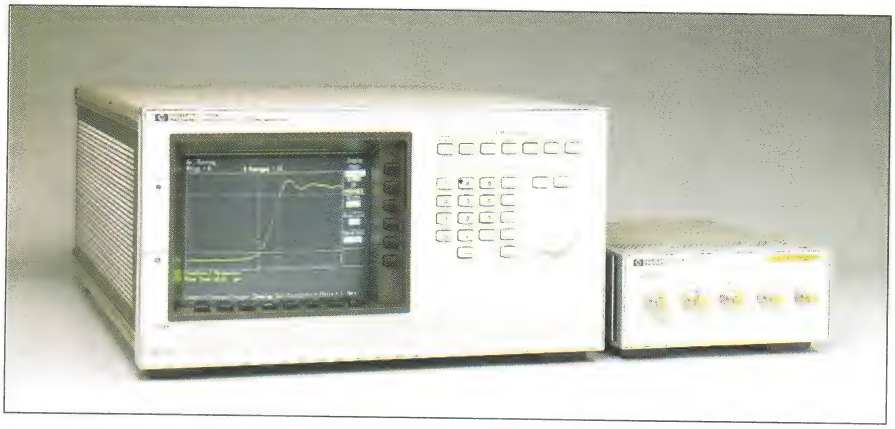
```
Total      10  Mask3    0  Mask7      Main Size
Wfms     5000  Mask4    3  Mask8       2ns/div
Mask1       0  Mask5    1  Mask9      Main Pos
Mask2       0  Mask6    0  Mask10      45.0ns
Persist/    Mask                      Remove/Clr Pan/
Histograms  Testing                   Trace 1    Zoom
Color Grad                             M1        Off
 Stopped                               Main
```

The CSA 803 provides mask testing, *using as many as 10 front-panel-input polygon masks with as many as 50 vertices on each polygon. The database and color display let you view the point density in each pixel on this eye pattern.*

HP specifies a typical sampling rate of approximately one-third the maximum value, depending on the processing load. Even though the 54123T samples data at a much slower rate, it will fill up a 500-point record more than 6 times/sec, which means you won't have to wait for a display on your screen. However, you may have to wait longer if you're building a large set of values for a histogram or if you're attempting to average many values. Therefore, speed is one of the significant advantages of the CSA 803.

Histograms are another area where the 54123T and the CSA 803 differ. Both DSOs provide automated measurements and support histograms, but the CSA 803 can save you more time.

The CSA 803 uses 16 bits of memory behind each pixel on the 512×256 waveform display to form a statistical database. Using the database, you can display any time or voltage histogram for the data captured until you change the acquisition setup. You can move time or voltage windows and instantly get a histogram. In addition, you can examine jitter and noise histograms from the same data. On the other hand, the 54123T lets you select a time or voltage window and then displays a histogram showing the voltage or time distribution that corresponds to the window. On the 54123T, whenever you move a window, you must acquire new data to form the histogram. If you're performing numerous histograms on large blocks of samples, the CSA 803 is a time saver.



The 34-GHz 54123T *from Hewlett-Packard uses digital feedback sampling for user-independent measurements. The normalization firmware simplifies time-domain-reflectometry measurements.*

Normalization eases calibration

In addition to the firmware routines that perform histograms and parameter measurements, the 54123T has a set of powerful normalization routines. Normalization lets you calibrate the instrument to a reference point where the device under test will be connected. The DSO-computed normalization filter nulls the effects of connecting cables and terminations, eliminating the errors caused by such hardware when making time-domain-reflectometry measurements.

To use the normalization capability, you must perform a firmware-controlled setup sequence. This setup sequence requires both a short circuit and a 50Ω load. The short calibration defines the reference plane corresponding to zero distance.

The normalization filter lets you see how a circuit responds to a step input that's faster or slower than the time-domain-reflectometry pulse source. For example, you can see how a circuit performs with a rise time that's equivalent to ECL. When using normalization, you must set the timebase and the delay so that you can view the reference point, and you must ensure that any point in the circuit you wish to examine is visible in the display. If you need to look at a point in the circuit that's far from your reference plane, you may be limited to a slower effective sweep speed. If you change the timebase or delay, you must perform the normalization setup sequence again.

The CSA 803 doesn't have a normalization capability for its time-domain-reflectometry system. It does have a computed rise-time filter that lets you observe the effect of a rise-time pulse that's slower than the step-generator pulse on a circuit under test. Because the CSA 803 uses a simple digital filter, it requires no special setup sequence.

The time-domain-reflectometry system for the CSA 803 has a reflected rise time of 35 psec compared with 45 psec for the 54123T. HP's normalization system lets you speed the 54123T's rise time, or computed effective results, to approximately 10 psec. The normalization filter can speed rise time by attenuating the lower frequencies and passing the higher frequencies. You can speed the computed rise-time results to about 10 psec before the noise content becomes unacceptable.

Both the 54123T and the CSA 803 have complete edge triggering as high as 2.5 GHz. Above 2.5 GHz, the CSA 803 has a divide-by-8 pres-

For more information . . .

For more information on the digital-storage oscilloscopes described in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

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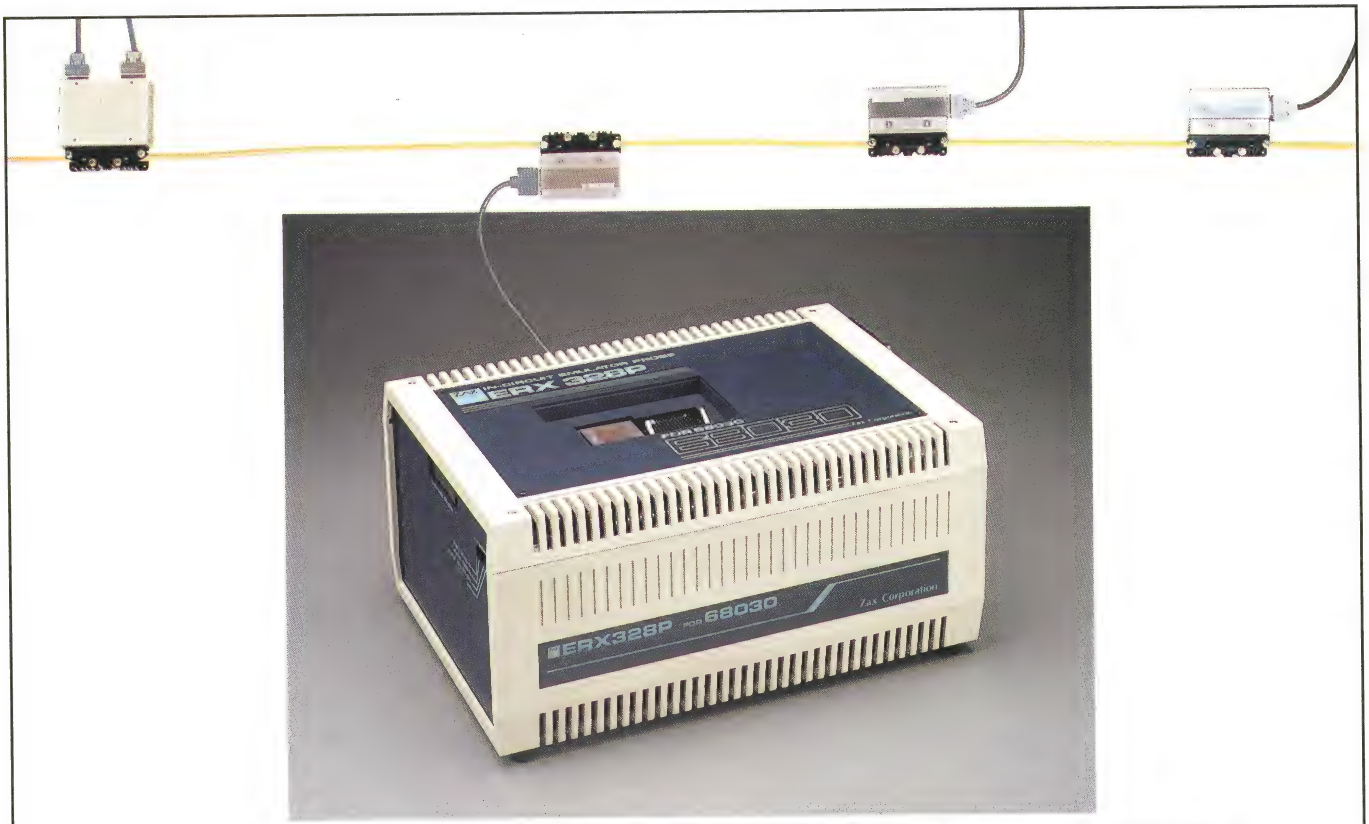

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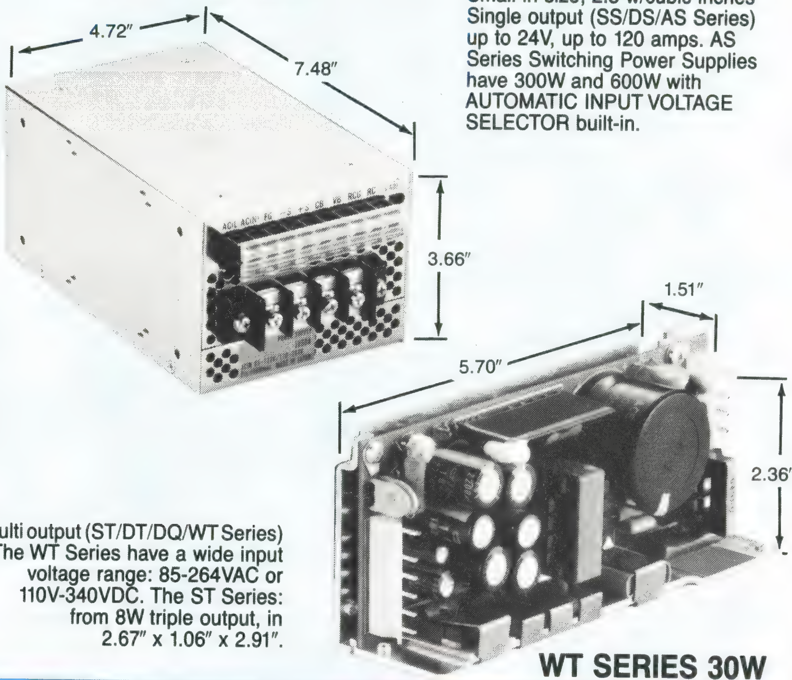

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caler for triggering on conventional digital waveforms as high as 10 GHz. The prescaler is limited, however. You can't use it to trigger on pulsed RF, for example, but it's useful for examining 9.6G bps digital data.

If the triggering capabilities of these two scopes aren't sufficient for your needs, both companies offer higher-bandwidth triggering capabilities. HP has the 54118A ($8925), which provides a full-capability edge trigger as high as 18 GHz. Tektronix offers the SD-51 trigger countdown head ($3000) for triggering as high as 20 GHz.

The 54123T costs $34,800. It comes standard with four channels, three of which have a 34-GHz bandwidth; the fourth is a 20-GHz channel for time-domain reflectometry. The CSA 803 mainframe costs $23,950 and doesn't include plug-ins (it has room for two plug-ins and two power-only plug-ins).

One plug-in for the CSA 803 is the SD-30, a single-channel plug-in that has a 40-GHz bandwidth and costs $9000. The SD-26, a 2-channel, 20-GHz plug-in, costs $3600. The SD-24 is a 2-channel, 20-GHz, sampling plug-in for time-domain reflectometry; it costs $5000. Another plug-in of interest for the CSA 803 is the SD-46 optical-to-electrical converter, which has a bandwidth of 20 GHz and costs $8500. These plug-ins can also be used in Tektronix's 11801 and 11802 mainframes. EDN

Reference

1. Conner, Doug, "Cut through the confusion surrounding high-performance DSOs," *EDN*, December 21, 1989, pg 78.

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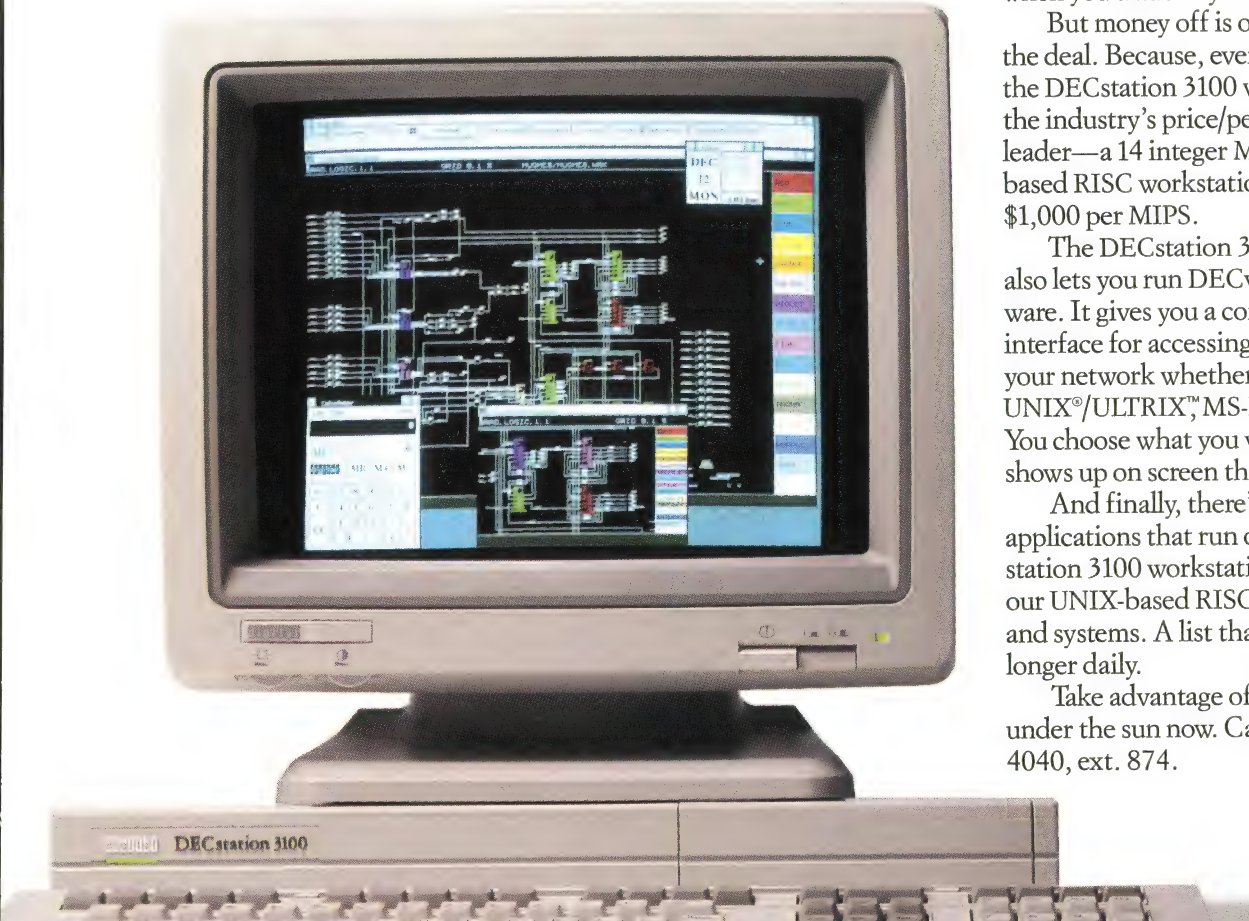

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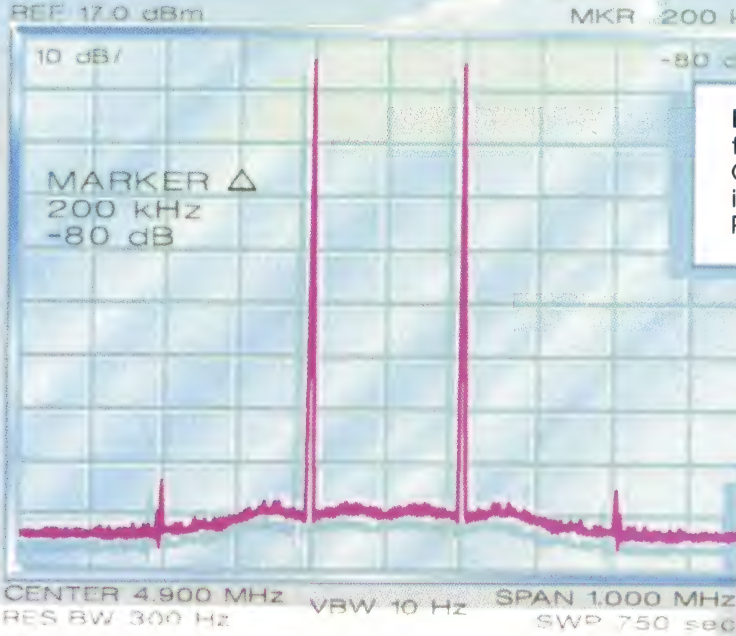

Legend:
f_1 = 4.8MHz, f_2 = 5.0MHz
G = 2V/V, V_{OUT} = $5V_{p-p}$ into 50Ω.
P_{OUT} = 12dBm/tone

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An internally compensated model, OPA620, is also available for unity-gain applications. Besides low distortion and high output drive, it settles to 0.01% in 25ns. Gain-bandwidth is 200MHz.

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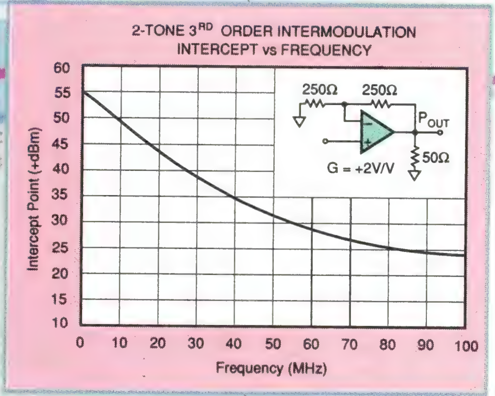
Burr-Brown makes it easy to put these parts to work in your system. The product data sheets include valuable charts and RF applications information. Demonstration PC boards are also available to speed layout and evaluation. You can also use our SPICE models; ask for AN-167. Contact your sales rep or call **1-800-548-6132** for immediate assistance.



Burr-Brown Corp.
P.O. Box 11400
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CIRCLE NO. 57

BURR-BROWN®

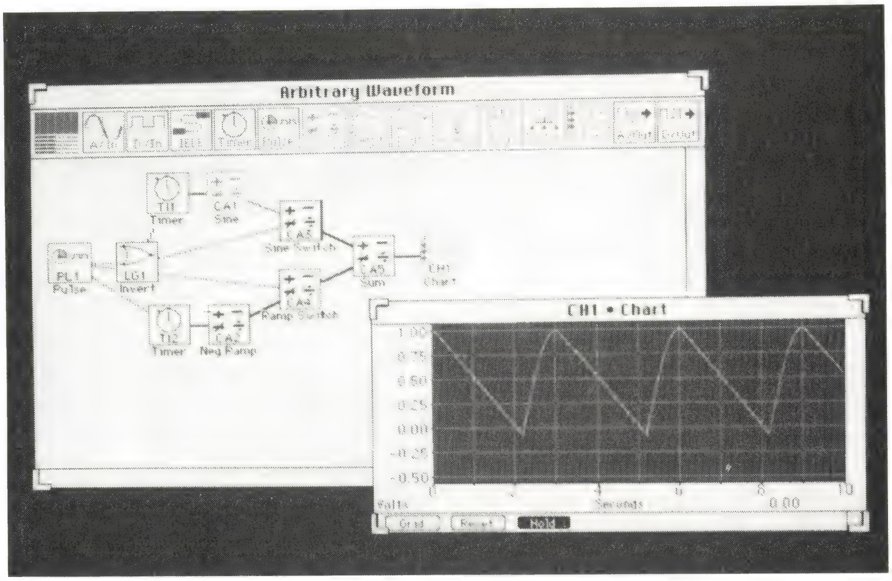
Icon-based instrument-control software works with PC bus data-acquisition boards

Two-thirds of the data-acquisition hardware products sold by Strawberry Tree Inc work with IBM PCs and compatible computers, yet the firm is best known for its Macintosh-based instrument-control software. This situation should change quickly, however, with the introduction of Workbench PC, an icon-based data-acquisition and instrument-control software package that runs on PCs. The software is similar to the company's 2-year-old Macintosh-based product, Analog Connection Workbench.

Using either package normally involves no programming. By using a mouse to interconnect icons on a computer screen, you configure your test setup and obtain a display of results in a form meaningful to you (for example, a strip-chart). The icons represent not only instruments but also calculations that the software performs.

Although Workbench PC isn't the only icon-based instrument-control package to run under MS-DOS, it's currently the only PC package with a graphical user interface that controls a large number of PC bus analog/digital I/O cards in addition to IEEE-488 instruments. The company's president agrees that some instrument-control packages running on PCs may offer greater power, but he claims that the firm's experience with its Macintosh-based product shows that Workbench PC will handle over 75% of PC-based data-acquisition problems.

In addition to allowing you to get your test setup running rapidly without programming, the software doesn't require you to purchase high-priced hardware. The package runs on virtually any PC-compatible computer with 640k bytes of RAM. It can even run on a machine having an 8088 CPU, two 720k-byte floppy-disk drives, a monochrome screen, and an IBM CGA display controller. Obviously, performance improves on machines with faster CPUs, arithmetic coprocessors, and hard-disk drives. Display quality improves when you use a display controller compatible with the IBM EGA standard.



Linking icons with Workbench PC *enables a D/A converter board to generate arbitrary waveforms, such as this sawtooth wave.*

You don't have to perform any compilation or linking steps to get Workbench PC's "programs" to run because the software contains an interpreter—one that operates in a nonpre-emptive multitasking mode. That is, when the output of one icon flows to two or more icons, the software handles the several processes almost concurrently. And unlike some other packages, the software lets you rapidly shift between a "programming" mode and a run mode where you can test your setups and modifications.

Only when controlling IEEE-488 instruments must you do anything that resembles classical programming. As yet, there are no drivers for specific IEEE-488 units, so you must type in the ASCII strings that constitute the messages such instruments recognize.

The software logs the data to text files that are compatible with such programs as Lotus 1-2-3, Excel, and dBase III. It can use setup files originally created with Analog Connection Workbench on a Macintosh and imported into MS-DOS. Conversely, you can export Workbench PC setup files to the Macintosh OS and use them with Analog Connection Workbench. Workbench PC costs $995. The vendor will make initial shipments in February.

—Dan Strassberg

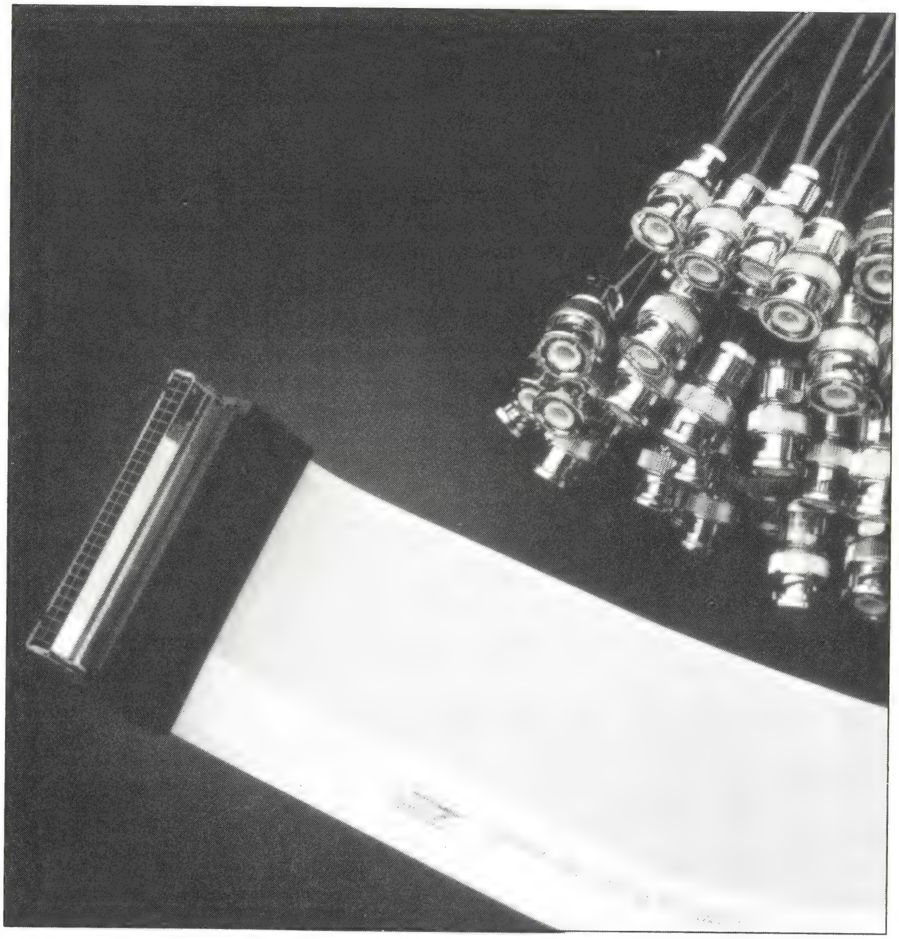
Strawberry Tree Inc, 160 S Wolfe Rd, Sunnyvale, CA 94086. Phone (408) 736-8800. FAX 408-736-1041. TWX 650-317-2834.

Circle No. 731

Low-cost ribbon cable minimizes signal crosstalk for near-coax performance

If you have a circuit that requires the high signal-fidelity characteristics of coaxial cable, switching to IDC ribbon cable may help you cut component costs from $2.50/signal line to less than $0.12 and slash your assembly costs to 1/60 of the present rate. This new controlled-impedance ribbon cable reduces signal crosstalk by as much as 50% when compared with fully shielded PVC cable. In addition, IDC ribbon cable facilitates high-density packaging because it has a lower profile than coaxial cable, routes easily, and is so flexible that you can bend the cable back on itself. The IDC cable is most attractive, however, because you can terminate as many as 60 signal lines with a single connector.

Coaxial cable requires individual line-terminations; you must attach a connector that costs around $1.25 to each end of each signal line. In other words, to terminate 60 coaxial signals, you would spend about $150 for connectors and make 20 terminations. In contrast, by using an IDC cable, you use only one $3.25 connector on each end of the cable and amortize the cost over as many as 60 signal lines; that is, to terminate 60 IDC-cable signals you would spend $6.50 for connectors and make two terminations.



***Providing significant savings in termination costs** as well as the low crosstalk characteristics of coaxial cable, Gore's controlled-impedance IDC ribbon cable replaces bulky, inflexible coaxial cable in applications that utilize high-speed signals.*

Again, when compared with shielded PVC ribbon cable, IDC cable provides higher signal fidelity and faster signal speed. PVC cable has 17.4-pF/ft capacitance, a 56% propagation velocity, a 1.8-nsec/ft time delay, and a 3.13 effective dielectric constant. A 50Ω IDC cable has 24.3-pF/ft capacitance, a 70% propagation velocity, a 1.45-nsec/ft time delay, and a 2.03 effective dielectric constant. Near-end and far-end crosstalk in a 10-ft length of single-ended IDC cable is typically less than 1% for signals with 5-nsec rise times, and as low as 2% if the rise time is 1.5 nsec. PVC ribbon cable specs are about 10 times as high.

Each line in an IDC cable has perforated copper-foil shielding and Gore-Tex composite insulation. You can order #30 or #28 AWG conductors plated with nickel or silver, or left unplated. The nickel-plated conductors offer the highest operating-temperature specifications, ranging from −65 to +260°C. The thermal resistance of the IDC cable meets MIL-STD specifications.

You can order IDC cables in ribbons composed of as many as 60 conductors, with or without drain wires, and with or without ruggedized jacketing. Available with 50, 75, or 95Ω impedance ratings, pricing for IDC cable begins at $0.30/conductor ft (OEM qty).

—J D Mosley

W L Gore & Associates Inc, Box 50699, Phoenix, AZ 85076. Phone (800) 228-3024; in AZ, (602) 431-0077.

Circle No. 732

PSpice

MicroSim Corporation

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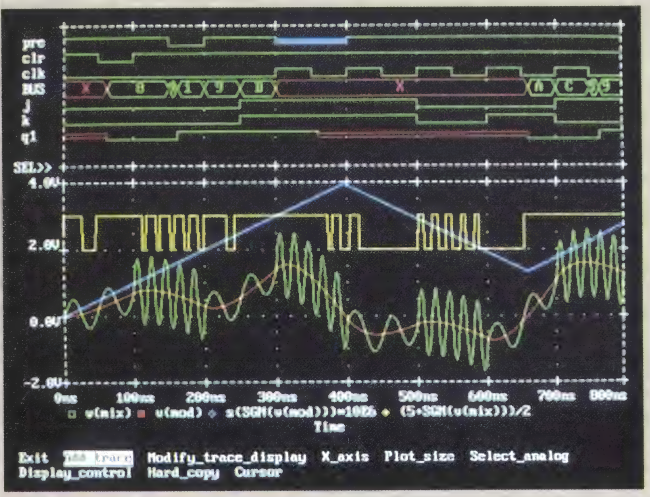

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Two years ago, MicroSim introduced the technology for simulating mixed analog/digital circuits. Now, this capability is available in the Digital Simulation extension for PSpice. It does true mixed-mode simulation of circuits – including feedback loops between analog and digital sections.

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PSpice with the Digital Simulation option:

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CIRCLE NO. 58

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CIRCLE NO. 59

PRODUCT UPDATE

A/D converter gives 20-bit resolution in audio band

If you handle digitized audio signals and demand top performance, consider the ADC20048 A/D converter. The 2-component set provides you with 20-bit resolution at a signal-to-noise ratio >110 dB for signals from 20 Hz to 20 kHz. Its differential nonlinearity is <0.1 LSB.

The set has two parts—the AFE 20048 analog front-end module and the D20C10 digital IC. The analog module measures 2×3×0.4 in. and contains an anti-aliasing filter, roll-off compensation, and a 128× oversampling A/D converter. The digital section is housed in a 48-pin plastic IC. It performs digital filtering on the analog module's output signal before presenting the data to the user.

The set achieves its noise performance through the use of a noise-shaping technique. The analog module adds high-frequency noise to the signal before sampling, thus shifting the converter's quantization noise well above the audio band. Because the converter is oversampling, the added noise is not aliased into the signal. The digital IC then uses a combination of FIR and decimator filters to take out both the quantization and the added noise, achieving 80-dB attenuation of frequencies >26 kHz and 0.1-dB passband ripple.

The set accepts differential analog signals having a range of ±3 or ±5V, and it provides digital-output data at either of two rates, 44.1 or 48 kHz. The digital data is available in both serial and parallel forms, using either 2's complement or offset binary coding. The parallel outputs have 3-state capability, so that you can connect the device directly to your system bus.

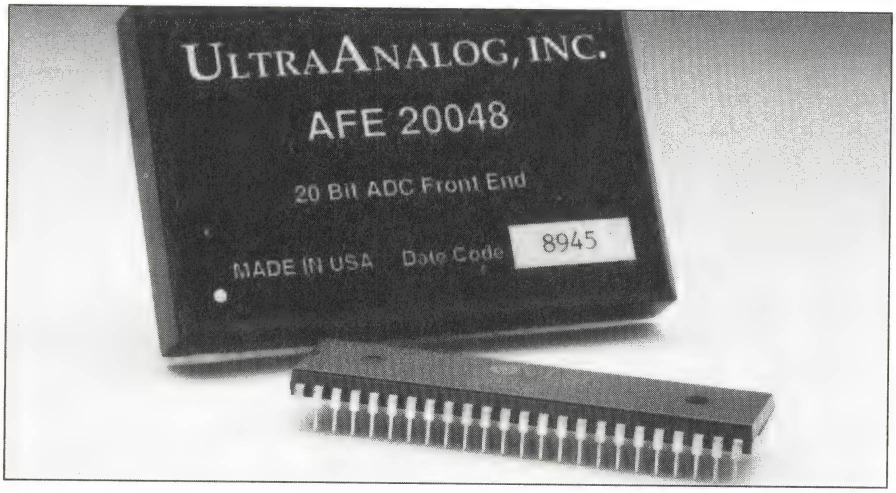
The A/D converter set operates from ±15 and 5V dc with a tolerance of ±0.25V. In addition, the ±15V supplies must be linear-regulated types in order to maintain the set's noise performance.

Power consumption for the pair is typically 2W. $275.

—***Richard A Quinnell***

UltraAnalog Inc, Box 14164, Fremont, CA 94539. Phone (415) 657-2227. FAX 415-657-4225.

Circle No. 733



The ADC20048, composed of this pair of devices, is a 20-bit audio A/D converter *that combines analog and DSP signal-conditioning techniques. The combination results in a S/N ratio >110 dB and a differential nonlinearity of <0.1 LSB.*

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Installation of probes and personality modules is effortless; the disassembly itself is more complete and informative than anything else in its class. You can have a complete 8-bit microprocessor debug package, including logic analyzer, for under $4000, and a 16-bit package for under $6000.

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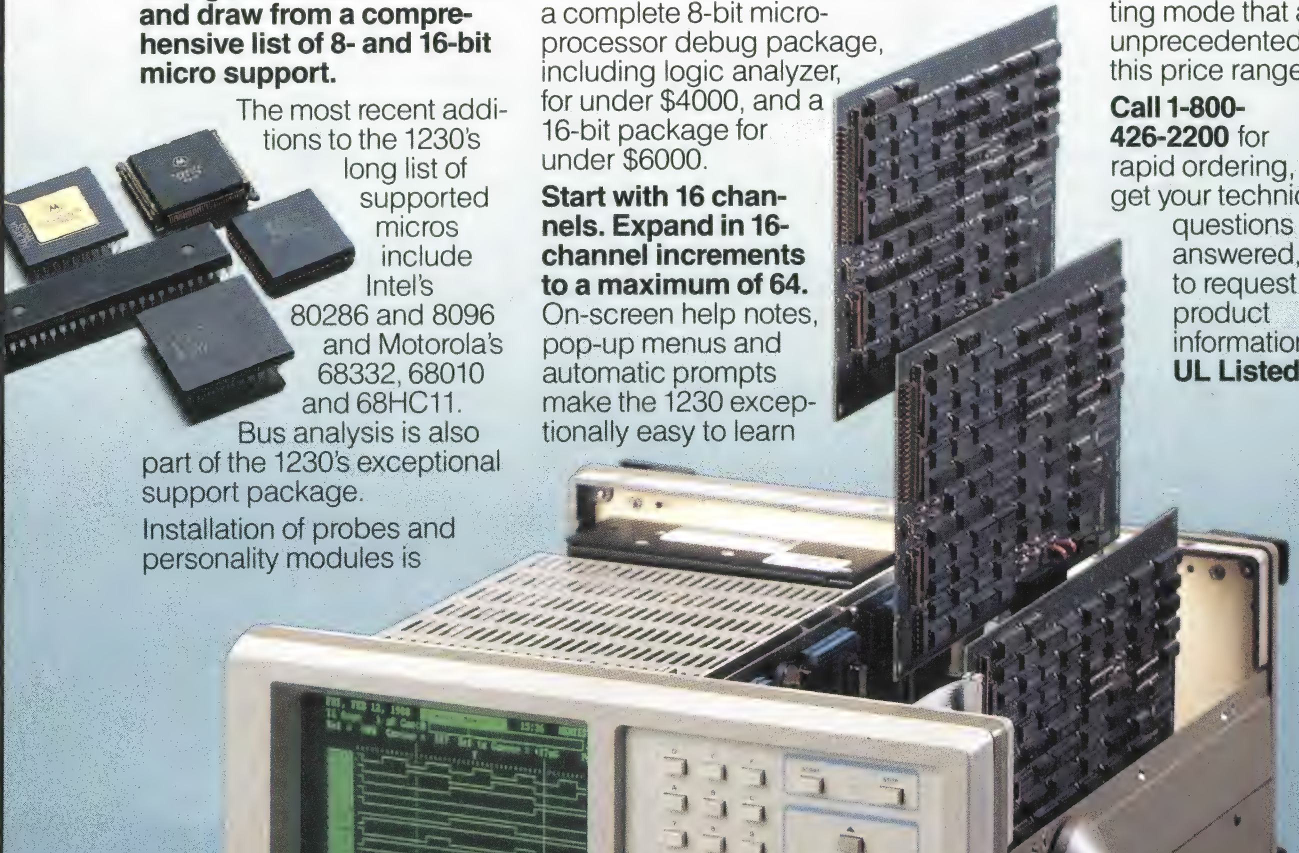

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EDN SPECIAL REPORT

Switched-capacitor filter ICs

Once considered noisy low-frequency devices suitable only for applications such as voice-grade telephony, switched-capacitor filter ICs have undergone a number of improvements. These compact, tunable devices offer many advantages over discrete-component filters and suit an increasing array of applications.

Richard A Quinnell, *Regional Editor*

With all the clang and clamor of modern life, every electronic signal representing real-world information can benefit from a filter that helps separate signal from noise. Yet designing and tuning a precision filter remains, to many engineers, a black art. Fortunately, there is an alternative to discrete-component filters that provides high-precision, tunable filtering in a single IC—the switched-capacitor filter (SCF).

Switched-capacitor filters are not new; they first appeared in IC form in the late 1970s. During their early years, however, SCFs acquired the reputation of being noisy and having limited frequency response—less than 30 kHz. As a result, they were used in only a limited number of applications.

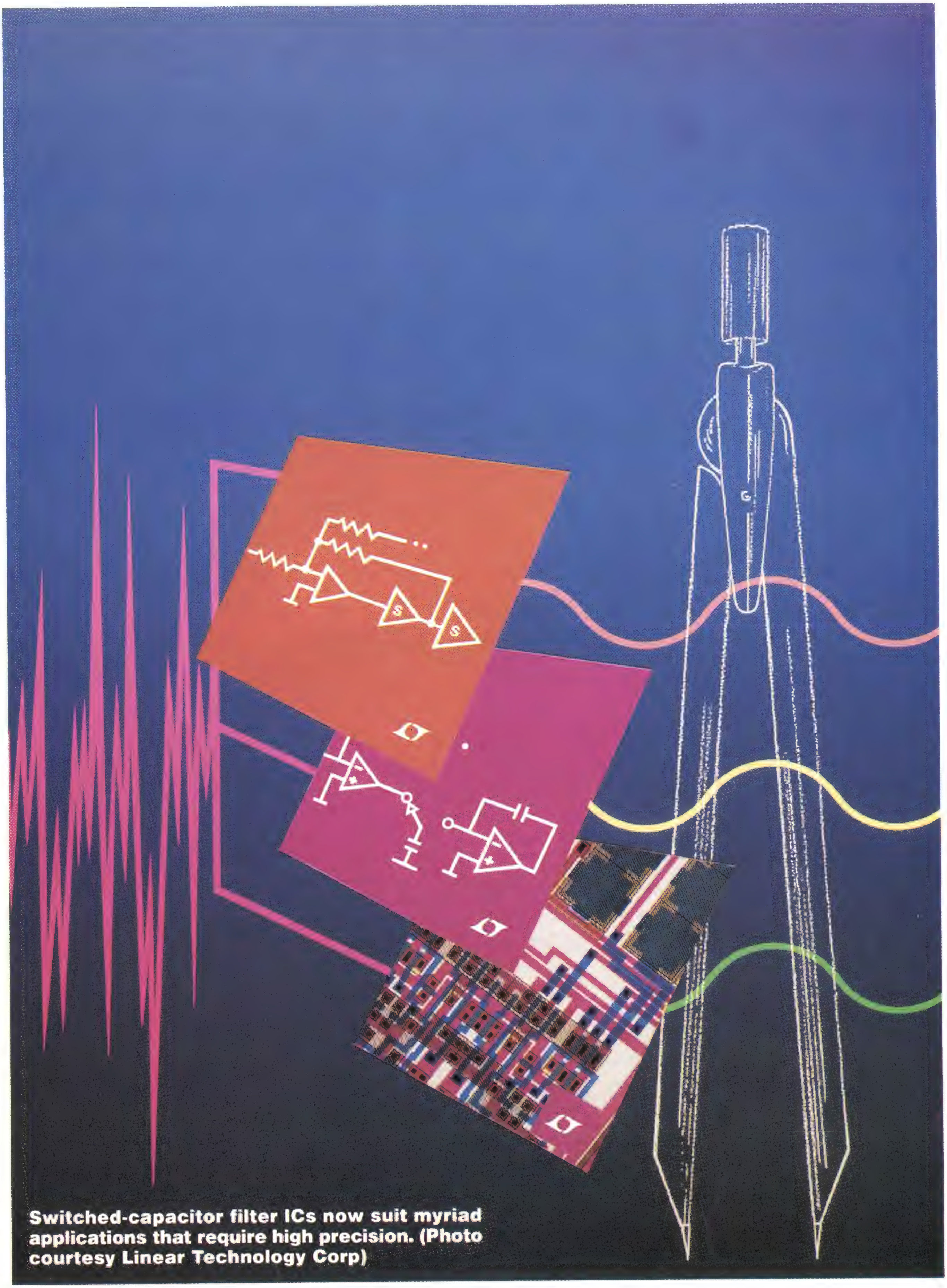
That reputation is no longer deserved. Technological changes during the last two years have resulted in a fourfold reduction in noise levels. And operating frequency has multiplied. National Semiconductor's LMF100, for example, operates to 100 kHz. Micro-Linear's ML-2111 stretches even further: It operates at frequencies as great as 150 kHz.

SCFs are based on the principle that a capacitor, if switched in the circuit, can be made to function as a resistor (**Fig 1a**). A switched-capacitor's effective resistance is proportional to the switching rate. Because the frequency response of an active filter is controlled by its resistor and capacitor values (**Fig 1b**), substituting a switched-capacitor for the resistor in a filter allows you to tune the filter simply by changing clock rates. This tuning ability is one of the primary benefits of SCFs.

Another benefit shows up when you try to create a monolithic filter IC. An active RC filter has a corner frequency that depends on the product of its component values. Because of the difficulty in controlling oxide thickness, IC capacitors typically have no better than 10% accuracy. Thus, your filter's frequency response may be in error by as much as 10%.

Don't think that monolithic active RC filters don't exist off the shelf, however. Precision Monolithics Inc, for example, offers the SSM-2044 4-pole lowpass active RC filter. It costs $2.60 (100) and comes in a 16-pin DIP. You adjust the filter's frequency response by supplying a control voltage. But such monolithic RC filters are rare; there is a much wider variety of switched-capacitor filter ICs available.

An SCF's corner frequency depends not on the product of its component values, but rather on the ratio of its capacitors. Despite the difficulty in fabricating IC capacitors with precise values, capacitor ratios are con-



Switched-capacitor filter ICs now suit myriad applications that require high precision. (Photo courtesy Linear Technology Corp)

Switched-capacitor filters substitute capacitors for the resistors in conventional filter design.

trollable to <1%. All the critical components of an SCF, therefore, can be integrated onto an IC without compromising accuracy.

Many monolithic SCFs are integrated as part of other functions and are hidden from the user. Still other stand-alone SCFs are dedicated to special functions. For example, Analog Devices offers the AD7431 transmit and AD7371 receive filters, costing $16.50 and $19.50 (100), respectively, for voice-band modems. **Tables 1** and **2** list general-purpose SCF ICs.

Choose universal or preconfigured filters

General-purpose SCFs come in two types: universal and preconfigured. The preconfigured types are the easiest to use. These devices implement a specific filter function—lowpass, bandpass, or notch—in one of the classic filter forms (see **box**, "A quick look at classic filters"). The preconfigured filters require no additional components and come in packages as small as 8-pin DIPs. All you need to do with these filters is supply a clock to set their frequency response.

A good example of the preconfigured type of SCF is the XR-1001/8 family from Exar Corp, which offers fourth-order Butterworth, Bessel, or Chebyshev lowpass filter forms in 8-pin DIPs and cost $1.30 to $1.55 (500). The filters can have corner frequencies as great as 40 kHz and a fixed clock-to-corner frequency ratio of either 50:1 or 100:1. The devices also have built-in oscillators, which give you the choice of either using an external clock or adding a resistor and a capacitor to set the corner frequency.

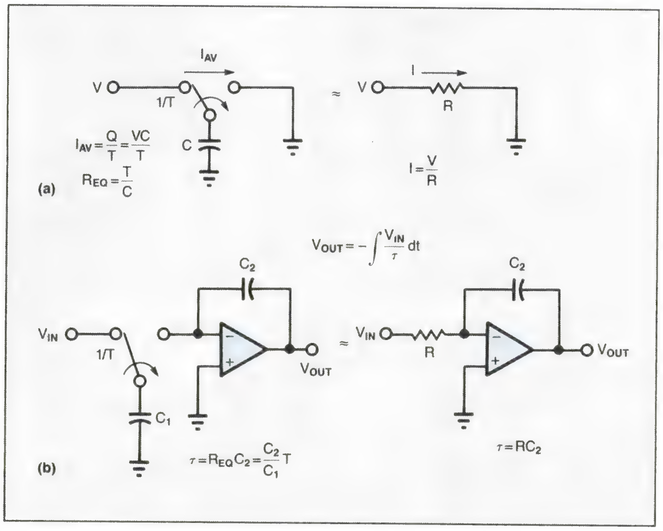


Fig 1—A capacitor (a) can be made to behave as a resistor when switched at a rate of 1/T. Its effective resistance is T/C; a switched-capacitor integrator **(b)** has its frequency response controlled by a capacitor ratio and the clock frequency.

Many switched-capacitor filter manufacturers offer design aids with their product lines. This filter development system from Crystal Semiconductor includes design software and an in-circuit emulator for the CS-7008.

Another preconfigured filter is National Semiconductor's LMF90, which provides a notch filter with a depth of 30 dB. Its clock-to-center frequency ratio is selectable at 33.3:1, 50:1, or 100:1, thus allowing you to filter a fundamental and its first two harmonics with a single clock. The device costs $3.10 (100).

If you can't find what you need in a preconfigured SCF, you can use a universal filter (see **box**, "What makes a filter universal?"). Universal filters contain all the active elements needed to build one or more second-order (biquad) filter sections. You create higher-order filters by cascading sections. The three basic types of universal filters are resistor programmed, pin programmed, and processor programmed.

Resistor-programmed universal filters offer you the greatest flexibility of any SCF. They allow precise control of corner or center frequencies and filter Qs. They all offer a nominal 50:1 or 100:1 clock-to-corner frequency ratio, which you can adjust with feedback resistors to obtain the proper ratio for your needs. Creating the proper filter characteristics for these devices is a fairly involved operation, however. You must

A quick look at classic filters

An ideal lowpass filter could be characterized by a single parameter—its cutoff (corner) frequency. It would have unity gain for frequencies in the passband; that is, those less than the cutoff frequency. The remaining frequencies above cutoff, the stopband, would receive infinite attenuation. The phase delay of signals passing through the filter would vary linearly with their frequency.

Real filters, however, cannot have such an abrupt behavior change at the cutoff frequency. Instead, they have a gradual gain roll-off from unity to -3 dB at the cutoff frequency. Beyond the cutoff, real filters exhibit a sharp roll-off to some maximum attenuation in their stopband. They may also have gain variations (ripple) in their passband.

Several approximations to the ideal filter have been developed and have attained the status of classics. These classic filter forms are the ones you can choose from when selecting a preconfigured filter or using a manufacturer's design tools. Each has its advantages; which one you should use depends on your application.

The first approximation (**Fig Aa**) is the Butterworth, or maximally flat, filter. An Nth-order Butterworth filter is flat at the beginning of its passband, rolls off gradually to its cutoff frequency, then rolls off at 10 × N dB/decade beyond the cutoff frequency.

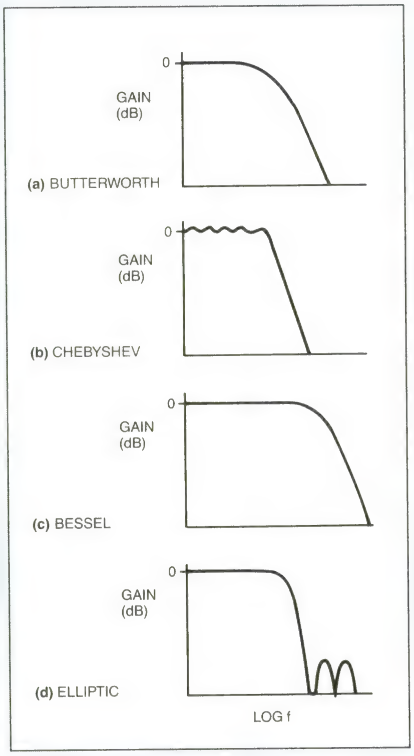


Fig A—Four classic filter forms, (a) Butterworth, (b) Chebyshev, (c) Bessel, and (d) Elliptic are available in switched-capacitor filters. The choice of which to use depends on your application.

The Chebyshev, or equal-ripple filter, (**Fig Ab**) has a sharper transition at cutoff than the Butterworth—at the expense of ripple in the passband.

Neither the Butterworth nor the Chebyshev filters has a linear-phase delay. They also both exhibit ringing in response to a step-input signal. The Bessel filter (**Fig Ac**) corrects both of these problems at the expense of a more gradual roll-off.

If very great attenuation is required at specific frequencies in the stopband, you can use the Elliptic, or Cauer filter (**Fig Ad**). This filter has zeros in the stopband and has greater roll-off than either the Butterworth or Chebyshev, which comes at the expense of ripple in both the passband and stopband and of a very nonlinear phase delay.

These classic filter forms are not limited to lowpass applications. They can also be used to implement highpass, bandpass, and notch functions.

Reference

National Semiconductor. *The Switched-capacitor Filter Handbook*. Santa Clara, CA, 1985.

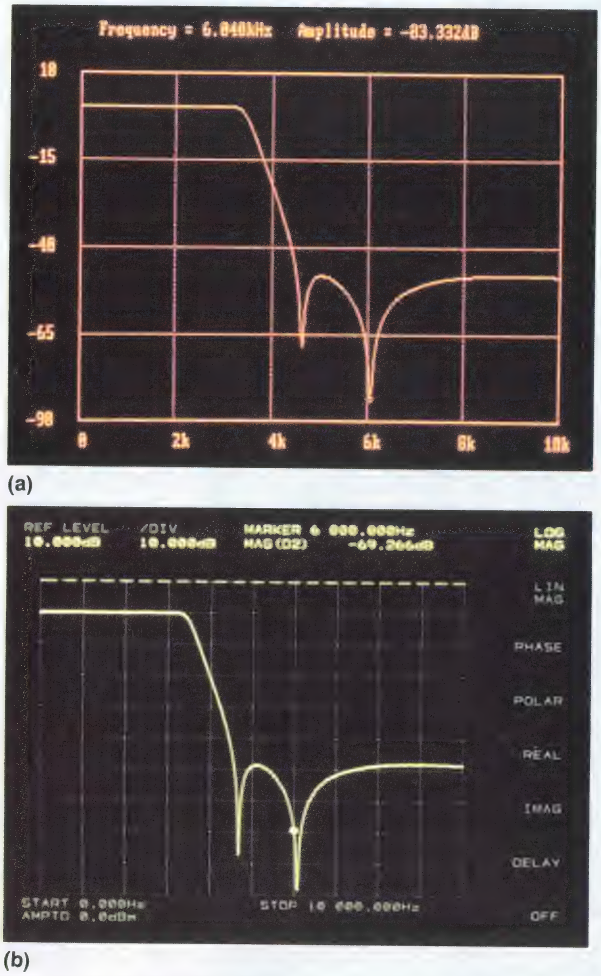
add three to six external feedback resistors for each section to set the filter's characteristics, so the term "resistor programmed" is a misnomer. Selecting the resistor values gives you an infinite number of operating points.

A compromise between flexibility and ease of use is found in programmed universal filters, either pin or processor programmed. Both types of devices replace the external resistors required by the other universal filters with additional switched capacitors. The capacitors are arranged in banks so that they can be combined in parallel under digital control, thereby allowing you to control all of the filter's characteristics. However, keep in mind that your operating points are limited by the number of control bits available.

In pin-programmed devices, such as Maxim's Max263 and Max264, you hardwire the coefficients to I/O pins, whereas most processor-programmable devices, as the

General-purpose SCFs come in two varieties, preconfigured and universal. The preconfigured types are the easier to use.

name implies, require a microprocessor. If your application has one, fine. If not, several manufacturers have addressed this concern in their processor-programmable devices. The CS-7008 from Crystal Semiconductor, for example, offers a self-programming mode, whereby it will generate address signals to read its programming data directly from a ROM, without the need for a microprocessor. The device has four biquad sections, and you can implement any even-order filter to eighth-order. You can digitally program the filter configuration and order, set a clock-frequency divider, and select capacitor ratios. The filter has 11-bit resolution on the capacitor ratios and 3-bit resolution for the divider ratio; the filter costs $30 (100).



(a)

(b)

Filter design software allows you to predict your filter's behavior. The software, available from many manufacturers, generates simulations (a) of your design that agree well with measured results (b). (Photo courtesy Sierra Semiconductor)

Another processor-programmed device that doesn't require you to have a processor is Sierra Semiconductor's SC22324. The programming coefficients are stored in EEPROM, allowing you to program the filter before installing it in your pc board.

An example of a processor-programmed device that does require a processor is Maxim's Max262. The device has two independent biquad sections and allows you to select the mode, Q, and clock-to-corner frequency ratio for each. There are 6 bits of resolution on the ratio, and 7 bits on Q. The device costs $11.96 (500).

Being able to select the filter's characteristics digitally doesn't ease the task of filter design, however. Whether the programming is digital or based on resistors, you will still need to figure out what values to select—a formidable task.

Here again, SCF manufacturers have strived to make your task easier. Many of them, including National, Linear Technology, Crystal, Sierra, and Maxim, offer filter-design software that runs on an IBM PC or compatible. These software packages handle many of the tedious calculations of filter design. They also allow you to play "what-if" games to evaluate tradeoffs between filter forms, Q, and frequency response.

The various software packages from each manufacturer operate in much the same way. You start by specifying your filter—selecting the filter form, corner and cutoff frequencies, and stopband attenuation desired. The program will then calculate the center frequency and Q required for each filter stage. Once you have a stage's center frequency and Q, or if you knew them to begin with, you can use a second routine to calculate the resistors or programming coefficients required to implement your filter with a particular manufacturer's parts.

The software also allows you to calculate and plot the frequency and phase characteristics of your final design. This last feature is especially helpful in analyzing the effects of component variations or quantization error on your design.

Current design software varies considerably in both cost and performance. National Semiconductor's software is free to customers, but can only handle filters up to tenth order. Further, the software only handles the classic filter forms. The filter-design kit from Sierra Semiconductor is more comprehensive, but costs $1875. For that price, you get software that calculates the programming coefficients for as many as four cascaded

SC22324 EEPROM-based filter ICs (32nd order); it also allows you to specify a general frequency response having a mixture of stopbands and passbands. In addition, the kit includes two filter ICs and programming hardware that is driven by your PC.

Crystal Semiconductor's $950 filter-design kit includes an in-circuit emulator that allows you to test your design's actual performance in your application.

Frequency isn't everything

Design packages allow you to accurately predict the frequency characteristics of your filter design. However, frequency is only one part of a filter's performance. As wonderful as SCFs are in theory, the real devices have some performance limitations that aren't handled by the manufacturer's design software. The most important of these are noise and output-voltage offset.

Noise in SCFs comes from a variety of sources. The transistors used as switches, for example, will inject some current into the capacitors while switching, creating noise at the clock frequency. In addition, the circuit elements generate thermal noise.

Because a switched capacitor is, in effect, a data

What makes a filter universal?

All the classic filter forms can be created by cascading second-order filter sections. The general expression for the transfer function of a second-order filter is

$$H(s)=\frac{V_{OUT}(s)}{V_{IN}(s)}=-\frac{As^2+Bs+C}{s^2+\frac{\omega_0}{Q}s+\omega_0^2}.$$

This type of filter is often called a biquad because it is the ratio of two quadratic functions.

You make the various filter types by selecting the appropriate values for A, B, and C. Lowpass filters, for example, would have $A=B=0$. Highpass filters would have $B=C=0$. A notch filter would combine the two types, requiring that $B=0$, whereas a bandpass filter would have $A=C=0$.

You can factor the transfer function to obtain the filter's output function. One such factorization is

$$V_{OUT}(s)=-\frac{1}{s}\left((B+As)V_{IN}+\frac{\omega_0}{Q}V_{OUT}-\omega_0V_1\right),$$

where:

$$V_1=-\frac{1}{s}\left(\frac{C}{\omega_0}V_{IN}+\omega_0V_{OUT}\right).$$

A block diagram of the circuit that shows this function is shown in **Figure Aa**. Two integrators and two summing junctions comprise the active circuit elements. Universal filter ICs earn their title because they contain those four elements.

The block diagram of a typical universal filter is shown in **Fig Ab**. By supplying resistors to create the necessary feedback paths, you can create the specific filter characteristics you need.

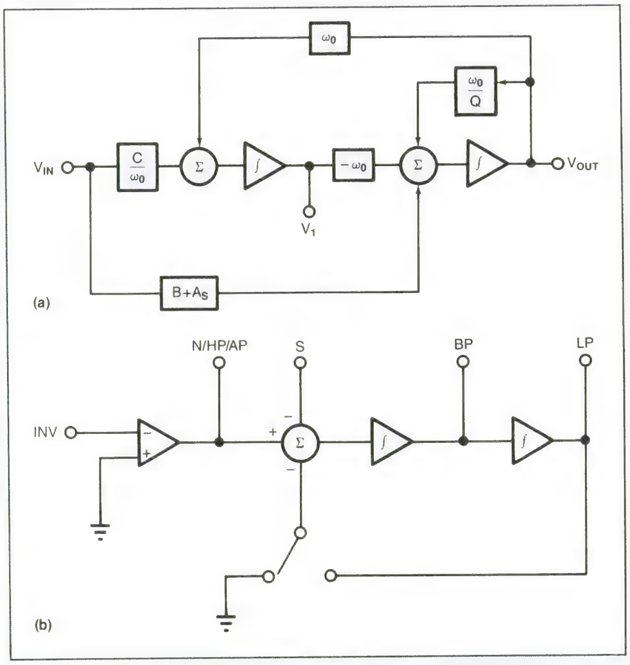


Fig A—A generic second-order filter response is attainable with just four active elements, (a) two integrators and two summing junctions. The universal-filter IC (b) offers the four elements and permits connection of the proper feedback elements.

Reference

Gregorian, Robik, and Gabor C Temes. *Analog MOS Integrated Circuits for Signal Processing.* John Wiley & Sons, New York, NY, 1986.

■

Programmable SCFs offer a combination of flexibility and ease of use, if you can tolerate the quantization of parameters.

■

sampler, SCFs also have all the noise sources of a sampled-data system. The filter's output waveform has a staircase appearance (**Fig 2a**), with resulting quantization noise at or above the clock frequency (**Fig 2b**). Incoming signals at frequencies greater than half the sampling clock are aliased and may appear in the filter's passband as noise.

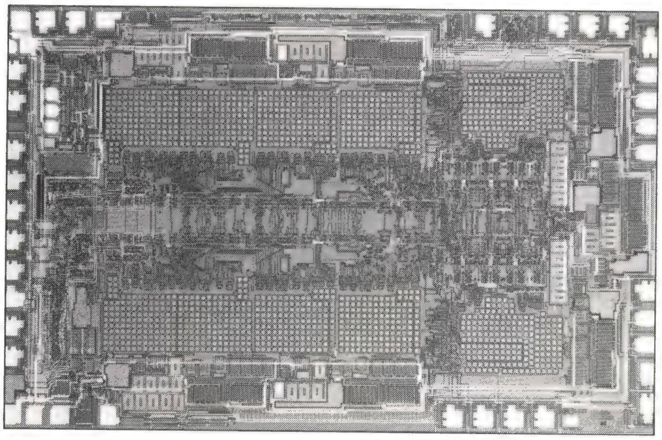
The first SCF products were fabricated in metal-gate CMOS and suffered greatly from both thermal and clock-feedthrough noise. An early industry standard, National Semiconductor's MF10 universal filter, had 10 mV of clock feedthrough and 400 μV rms of broadband noise.

Output-voltage offset is a consideration

A second limitation to consider is output-voltage offset. Another early device, National Semiconductor's MF4 fourth-order Butterworth filter, had as much as 400-mV dc offset. Depending on the mode being used and resistor values selected, the MF10's lowpass filter output could exhibit offsets of several volts.

Devices introduced since 1987, however, use polysilicon-gate CMOS and improve on one or more of these specifications. In terms of offset voltage, for example, the LMF100, National's MF10 upgrade, has offsets that are only 20% that of the MF10. National's LMF40, an upgrade of the MF4, has a maximum offset voltage of 100 mV. Similarly, their noise characteristics are a fourfold improvement on the older devices. The LMF100 costs $2.50; the LMF40 costs $2.19 (100).

Given that noise and offset exist in SCFs, there are a number of design decisions you can make that will help you get the most from the devices. For example, you can trade dc offset for other operating characteristics in your component selection. Maxim's Max260 and Max261 are both programmable universal filters. The Max261 has a frequency range of 0.4 Hz to 57 kHz. Its cousin, the Max260, has a frequency range of .01 Hz to 7.5 kHz but only ⅛ the offset. Both devices cost $9.41.



Banks of capacitors give processor-programmable switched-capacitor filters their flexibility. On-chip digital logic allows you to connect capacitors as needed to tune the filter. (Photo courtesy Maxim Integrated Products)

Filters without any output offset are also available. Linear Technology offers the LTC-1062, a fourth-order dc-accurate Butterworth lowpass filter that is designed to be used in conjunction with an external RC circuit (**Fig 3**), providing an overall fifth-order response. The dc-accurate output is unbuffered, however, and has limited drive capability.

If you need greater drive, the LTC-1062 includes an uncommitted op amp that can be used to buffer the output. The op amp adds a dc offset of <20 mV. The LTC-1062 costs $3.50 (100).

Maxim also offers a dc-accurate lowpass filter, the

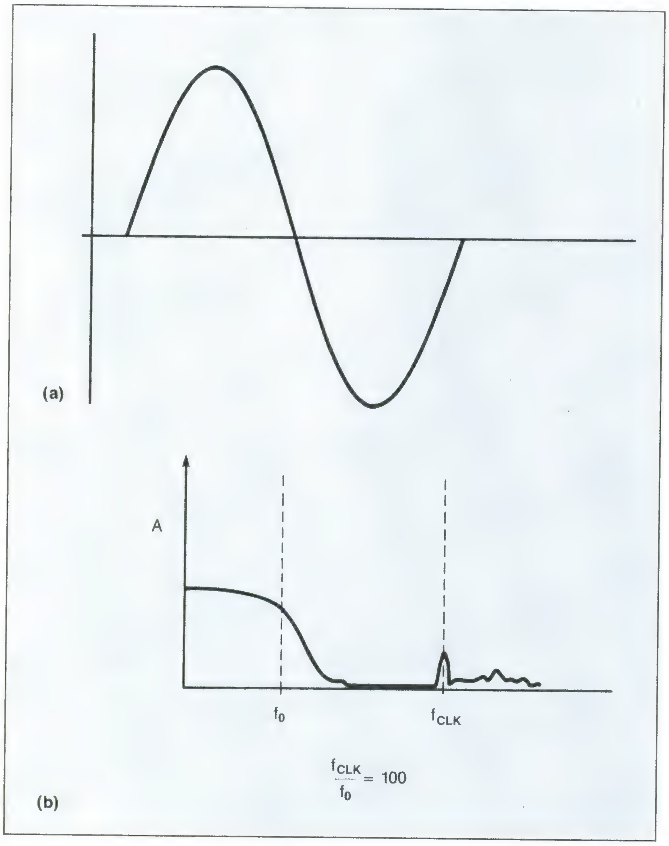


Fig 2—The output of a switched-capacitor filter (a) only looks bad. The noise in the signal (b) is at the clocking frequency, 100 times the frequencies of interest.

Max280. This device is functionally identical to the LTC-1062, but offers an improved buffer. Its uncommitted op amp has an offset of <2 mV. The Max280 costs $3.30 (100).

Careful design of SCFs can control both the noise characteristics and their offsets. Aliasing can be limited by adding a simple RC filter before the SCF. The requirements of this prefilter are relatively mild because the sampling frequency is well removed from your desired signals. Clock-to-corner frequency ratios are typically 50:1 or 100:1.

Similarly, you can limit clock-feedthrough and quan-

Table 1—Representative universal filters

	Company	Part number	Center-frequency range (Hz)	Clock-to-center accuracy (%)	Clock feedthrough (mV p-p)	Wideband noise (μV RMS)	Number of filter sections	Crosstalk attenuation (dB)	Supply voltage (V)	Maximum supply current (mA)	Cost (100)
Resistor programmed	**EG&G Reticon**	RU5621A	1–30k	60.5	45 mV (RMS)	240	2	60	±5–±10	4	$3.15
	Exar	XR-1010	0.1–30k	0.6	30	—	2	78	6–10.5 or ±3–±5.5	15	$2.30
	Linear Technology	LTC-1059	0.1–40k	0.8	10	240	1	N/A	4.75–18 or ±2.37–±9	5.5	$3.25
		LTC-1060	0.1–30k	0.8	10	240	2	70	4.75–18 or ±2.37–±9	8	$3.90
		LTC-1061	0.1–35k	1.2	0.4 mV (RMS)	200	3	60	4.75–18 or ±2.37–±9	12	$8.25
		LTC-1064	0.1–140k	0.3	0.2 mV (RMS)	100	4	65	4.75–16 or ±2.37–±8	16	$8.40
	Maxim Integrated Products	MAX265	0.4–57k	0.2	2	247	2	70	5 or ±5	29	$9.41
		MAX266	0.4–140	0.2	8	247	2	70	5 or ±5	29	$10.59
	Micro Linear	ML-2110	25–30k	0.3	10	320	2	70	4–12 or ±2–±6	22	$3.75
		ML-2111	25–150k	0.4	10	342	2	50	4–12 or ±2–±6	22	$6.95
	National Semiconductor	LMF-100	0.1–100k	0.2	6	300	2	60	4–15 or ±2–±7.5	13	$2.50
		LMF-120	0.1–100k	0.5	10 mV (RMS)	250	6	60	4–15 or ±2–±7.5	10	$5000 NRB (Note 3)
	Texas Instruments	TLC-10/ MF10A	0.1–30k	0.6	10	—	2	60	±5	10	$3.57 (500)
		TLC-20/ MF10C	0.1–20k	1	10	—	2	60	±5	10	$2.02 (500)
Pin programmed	**EG&G Reticon**	RU5620A	10–20k	3	30 mV (RMS)	270	1	N/A	±5–±10	10	$4.70
	MX-Com	MX406	100–5k	—	5	—	2	—	5	3	$5.63
	Maxim Integrated Products	MAX263	0.4–57k	0.2	8	247	2	70	5 or ±5	20	$9.41
		MAX264	1–140k	0.2	8	247	2	70	5 or ±5	20	$11.76
Processor programmed	**Crystal Semiconductor**	CS-7008	5–50k	(Note 4)	40	480 (max)	1 (eighth order)	N/A	±5	25	$30
	Maxim Integrated Products	MAX260	0.1–7.5k	0.2	8	220	2	70	5 or ±5	20	$9.41
		MAX261	0.4–57k	0.2	8	247	2	70	5 or ±5	20	$9.41
		MAX262	1–140k	0.2	8	247	2	70	5 or ±5	20	$11.76
	Sierra Semiconductor	SC22322	25–100k	(Note 5)	(Note 5)	(Note 5)	2	(Note 5)	±5	20 (typ)	$6
		SC22324	25–100k	(Note 5)	(Note 5)	(Note 5)	4	(Note 5)	±5	20 (typ)	$49

Notes: (1) All values typical. Operating conditions: $V_S = \pm 5V$ dc, lowpass filter, 0=10, Ta=25°C.
(2) Output dc offset for universal filters varies with resistor choice.
(3) This part is a mask-programmed version of the LMF-100.
(4) Varies with configuration.
(5) Not specified. This part is intended as a prototyping tool for an ASIC design.

Many manufacturers offer filter development programs. These programs ease the tedium of calculating filter response characteristics.

tization noise by adding a smoothing postfilter. Some SCFs offer uncommitted op amps in the filter IC, allowing you to add prefilters or postfilters without needing more ICs. Maxim's Max255 and -256, for example, include two uncommitted op amps as part of the package.

If your incoming signals are <2V, you may also be able to reduce noise and increase your signal-to-noise ratio by operating the SCF at a lower supply voltage.

Table 2—Representative special filters

	Company	Part number	Corner-frequency range (Hz)	Clock-to-center accuracy (%)	Clock feedthrough (mV p-p)	Wideband noise (μV RMS)	Maximum dc offset (mV)	Filter order	Supply voltage (V)	Supply current (mA)	Cost (100)
Bessel lowpass	**Exar**	XR-1003	0.1–25k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.51 (500)
		XR-1004	0.1–30k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.51 (500)
	Linear Technology	LTC-1064-3	0.1–95k	0.6	200 μV	55	150	8	4.75–16 or ±2.37–±8	20	$9.95
Butterworth lowpass	**Exar**	XR-1001	0.1–25k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.30 (500)
		XR-1002	0.1–30k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.30 (500)
	Linear Technology	LTC-1062	0–20k	1	1	100	0 (20) (Note 2)	5 (Note 3)	5–18 or ±2.5–±9	7	$3.55
	National Semiconductor	LMF-40	0.1–40k	1	5	100	100	4	4–14 or ±2–±7	5	$2.19
		LMF-60	0.1–30k	1	10	100	150	6	4–14 or ±2–±7	6.5	$3.50
	Maxim Integrated Products	MAX280	0–20k	1	10	90	0 (2) (Note 2)	5 (Note 3)	4.75–16 or ±2.37–±8	7	$3.30
	Texas Instruments	TLC-04/ MF4A-50	0.1–40k	0.8	7	142	150	4	±2.25–±6	3	$1.09 (500)
		TLC-14/ MF4A-100	0.05–20k	1	7	178	200	4	±2.25–±6	3	$1.09 (500)
Elliptic (Cauer) lowpass	**EG&G Reticon**	RF6609A	10–25k	1	7 mV (RMS)	240	160	7	±5	9	$5.50
	Exar	XR-1015	0.1–25k	1	30	600	600	7	4.75–10.5 or ±2.38–±5.25	11	$5.19 (500)
		XR-1016	0.1–25k	1	30	600	600	7	4.75–10.5 or ±2.38–±5.25	11	$5.97 (500)
	Linear Technology	LTC-1064-4	0.1–100k	0.6	8	120	160	8	±2.37–±8	20	$14.20
Chebyshev lowpass (0.1 dB)	**Exar**	XR-1005	0.1–25k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.55
		XR-1006	0.1–30k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.55
Chebyshev lowpass (0.5 dB)	**Exar**	XR-1007	0.1–25k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.51
		XR-1008	0.1–30k	1	50	500	400	4	4.5–11 or ±2.25–±5.5	3.5	$1.51
Bandpass	**Maxim Integrated Products**	MAX267	0.4–57k	1	8	100	50	2×2	5 or ±5	20	$9.41
		MAX268	1–140k	1	8	100	50	2×2	5 or ±5	20	$11.18
Notch	**National Semiconductor**	LMF-90	0.1–30k	1.5	50	370	140	4	4–15 or ±2–±7.5	5	$3.10
Highpass	**EG&G Reticon**	RF5611A	10–5k	3	30 mV (RMS)	1000	600	5	±5–±10	16	$5.75

Notes: (1) All values typical. Operating conditions: $V_S = \pm 5V$, Q=10, Ta=25°C.
(2) Refers to offset of on-chip buffer.
(3) Includes user-supplied RC stage.

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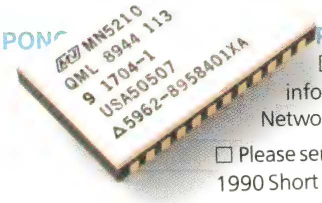

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Noise and output-voltage offset in SCFs contributed to their prior bad reputation. Newer devices greatly reduce both, but careful board design is still the rule.

National's LMF100, for example, has 6-mV clock feedthrough and 300-μV wideband noise if operated at its full ±5V supply. The numbers drop to 2 mV and 220 μV for ±2.5V operation.

Another method of improving signal-to-noise ratios for low-level signals is to boost the signal strength before filtering. If harmonic distortion is a concern for you, however, operating with larger signals may not be the answer. The harmonic distortion of many SCFs increases dramatically with signal strength (**Fig 4**).

Careful pc-board layout will also help control noise. The clock signal is a good target for your attention. It forces you to design for higher frequencies than your incoming signal warrants because its frequency is 50 to 100 times greater than your signal frequencies. Any overshoot on the clock signal will contribute to filter noise by injecting current into the switched capacitor through the ICs' input-protection diodes. Further, SCFs are sensitive to power-supply noise, thereby requiring you to use adequate decoupling to maintain overall noise performance.

You can reduce noise in cascaded filters by putting the higher-Q filter sections first in the series. Be aware of the section's behavior near the cutoff frequency, however, or you may suffer from signal distortion due to clipping. Rather than pass signals uniformly, a biquad filter with high Q amplifies signals near the cutoff frequency, a phenomenon known as gain peaking, which may cause clipping in the filter section's integrators. If gain peaking is a problem, you will need

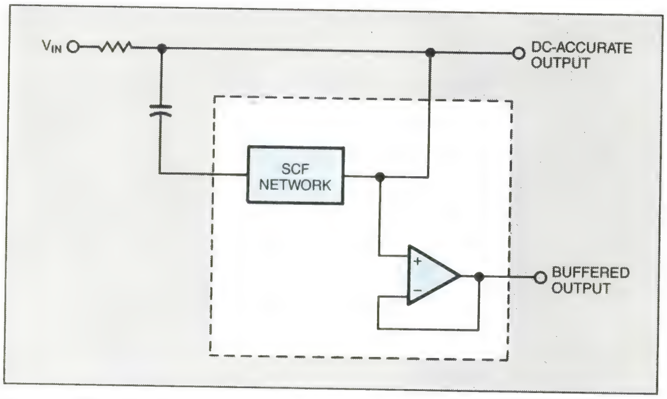

Fig 3—This novel structure provides a dc-accurate signal with a switched-capacitor filter. Both the Linear Technology's LTC-1062 and Maxim Integrated Products' Max280 offer this filter type.

Manufacturers of switched-capacitor filter ICs

For more information on filter ICs such as those described in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

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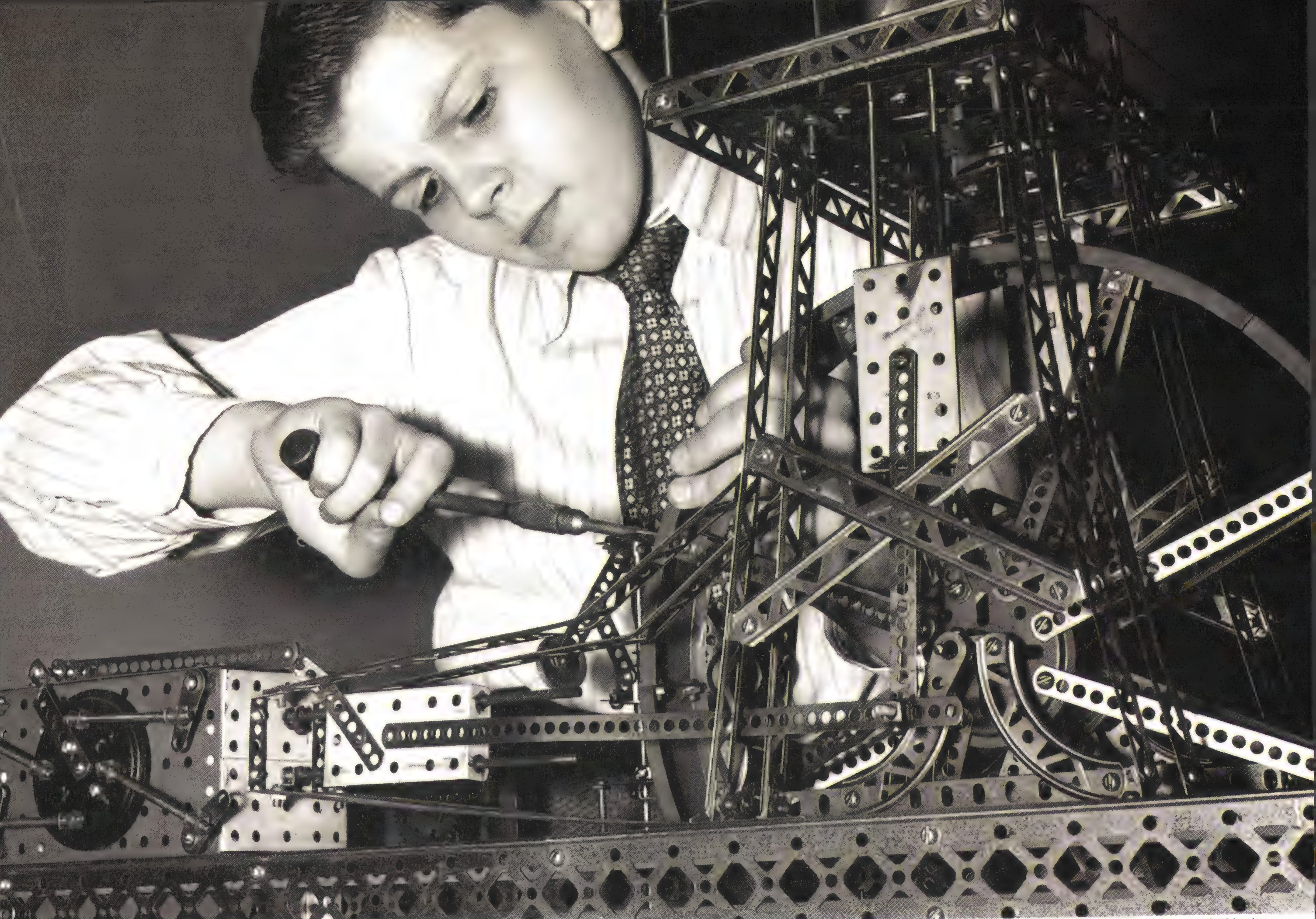

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Manufacturers predict that SCFs will soon attain 500-kHz capability.

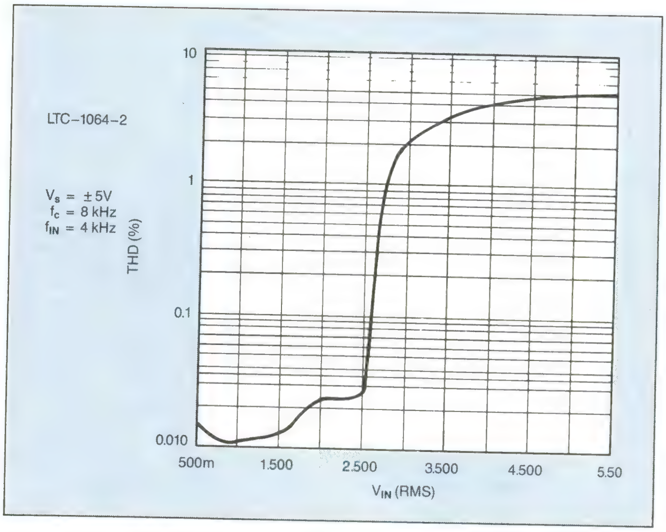

Fig 4—Total harmonic distortion in switched-capacitor filters abruptly increases with increasing voltage. If your filtering application requires low distortion, be sure to control the input signal's strength.

to place the low-Q sections first.

In the past few years, switched-capacitor filters have evolved substantially. Instead of just voice-grade telephony, today's devices suit such demanding applications as audio spectrum analysis, DSP prefiltering, sonar, telecommunications, and instrumentation-noise filtering. According to some manufacturers, the range of applications will soon stretch to encompass RF. With today's processes, they claim, SCFs can be made that operate to 500 kHz. **EDN**

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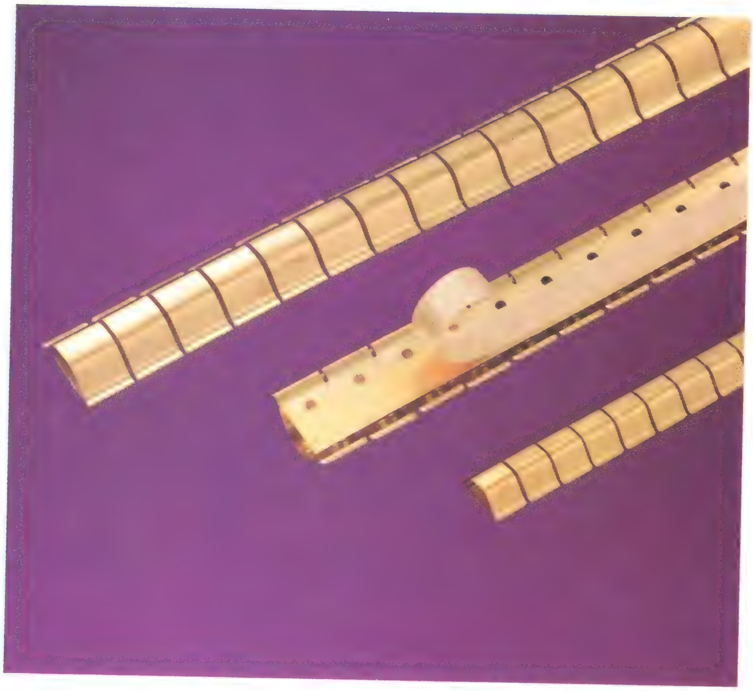

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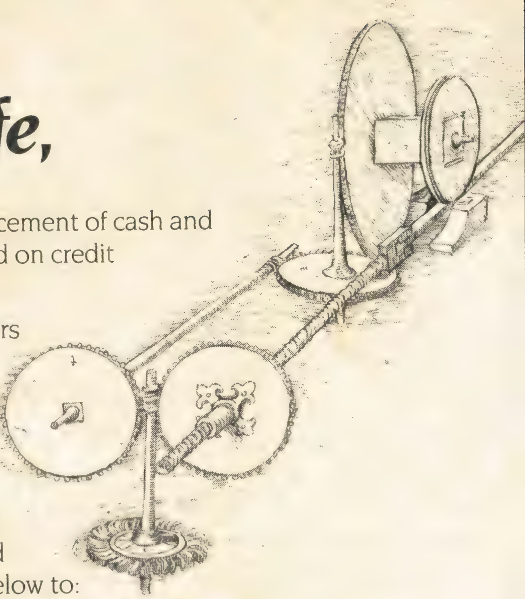

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Transaction Fee For Cash Advances, And Fees For Paying Late Or Exceeding The Credit Limit	Transaction Fee For Bank and ATM Cash Advances: 2% of each Cash Advance, $2 Minimum, $25 Maximum Transaction Fee For Access Check Cash Advances: 1% of each Cash Advance, $2 Minimum, $10 Maximum Late Payment Fee: $15; Over-the-Credit-Limit Fee: $15

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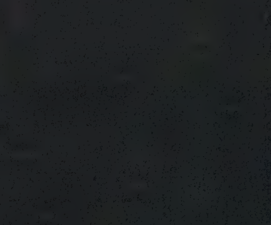

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DESIGNER'S GUIDE

flash–ADC testing
Part 1

Flash ADCs provide the basis for high-speed conversion

Building high-performance circuits that take advantage of the high sampling rates of flash ADCs requires a knowledge of these converters' many intricacies. Part 1 of this 3-part series discusses the pitfalls of designing with flash ADCs, how to evaluate certain data-sheet specifications, and how to choose external components that complement your particular converter. Parts 2 and 3 will explore test and measurement methods that you can use to verify a converter's performance in your system.

Walt Kester, *Computer Labs Div, Analog Devices*

To digitize analog signals whose bandwidths exceed 1 MHz, you'll probably need flash ADCs. Many flash converters with 4 to 10 bits of resolution are now available, thanks to recent advances in VLSI process technology and design techniques. However, to use these converters successfully at the high sampling rates that they provide, you must take into account and compensate for a variety of flash-converter characteristics.

The basic features of most flash converters are shown in **Fig 1**. A flash ADC simultaneously applies an analog-input signal to 2^N-1 latched comparators, where N is the number of the converter's output bits. A resistive voltage divider generates each comparator's reference voltage and sets each reference level 1 LSB higher than the level of the comparator immediately below it. Comparators that have a reference voltage below the input-signal level will assume a logic 1. The comparators with a reference voltage above the level of the input signal will produce a logic 0. A secondary logic stage decodes the thermometer code that results from the 2^N-1 comparisons. An optional output register latches the decoding stage's digital output for one clock cycle.

Timing is everything

One of the first difficulties you'll encounter when using flash converters is removing valid data from the converter. In practice, the comparator bank has two states controlled by a conversion-command signal. Various converters call this command the convert, the encode, or simply the clock command. When this signal is in its convert-command state, the comparators track the analog-input signal, and during this time the output data is invalid. When the command line changes state, it latches the comparator outputs. Valid output data is now available for transfer to an external register. You'll find most flash converters somewhat sensitive to the duty cycle and frequency of this command pulse. In other words, the performance of the converter, specifically its differential and integral nonlinearity performance, is related to the clock's duty cycle and frequency. Performance degradation is especially pronounced when you run the device at or near its maximum sampling rate.

Because of recent advances in VLSI processing and design techniques, many flash converters that have from 4 to 10 bits of resolution are available.

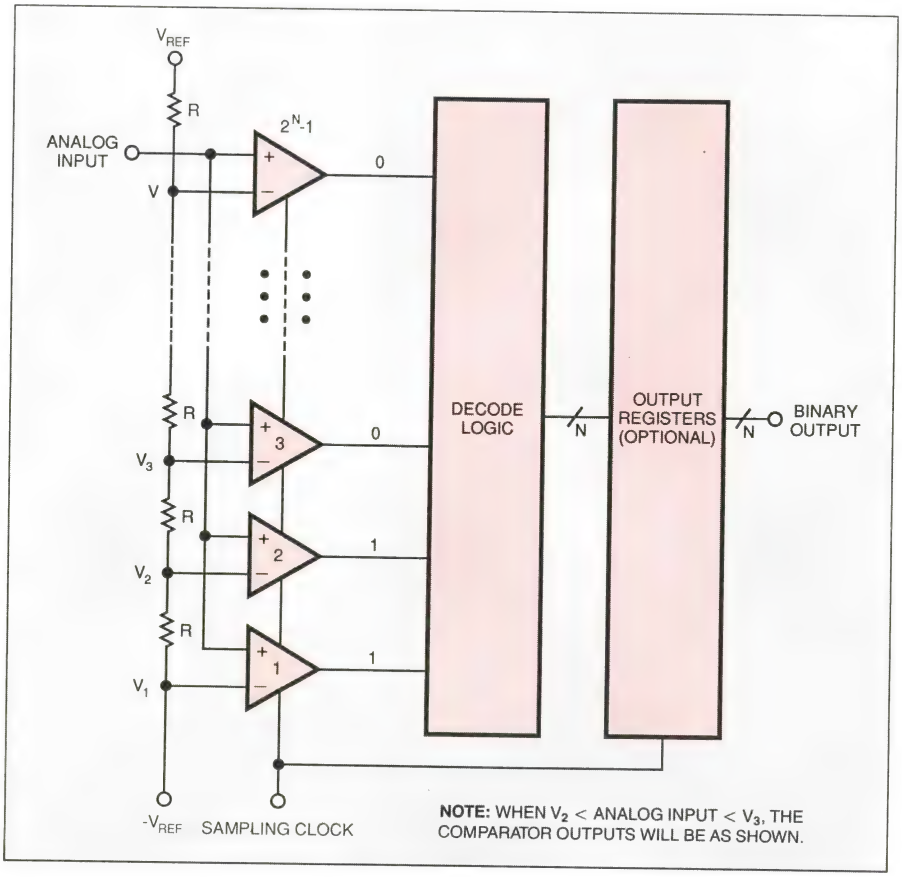
The way you handle the binary output depends on whether the converter has an internal output latch. Without a latch, the data will be invalid for a period equal to the sampling clock's pulse width. At high sample rates, the data-invalid time will impinge on the data-valid time, making it difficult for you to strobe the flash converter's output into an external register. For instance, if you operate a flash converter at 100M samples/sec with a 50%-duty-cycle sampling clock, the output data will be valid for only 5 nsec. When you consider the finite rise and fall time of the output binary bits, this short time doesn't leave you much leeway, even if you use the fastest external logic. In fact, you may ultimately lose data. The addition of an internal output latch simplifies clocking of the output data, because the output data is valid for approximately the entire clock cycle. In return for a longer data-valid time, you'll have to accept an inherent 1-cycle or more pipeline delay—an acceptable compromise in most systems applications.

Try to place an appropriate buffer register next to the flash converter. If you route the converter's digital output directly to a backplane data bus through a card-edge connector, signal coupling between the digital-output signals and analog input will degrade the S/N ratio and harmonic performance.

In many high-speed data-acquisition designs, you'll need a large and fast buffer memory to store the output data. A 500M-sample/sec converter can fill 1M byte of memory in 2 msec. To reduce the required speed—and thus the cost—of the memory, you can demultiplex the high-speed data stream (**Fig 2**), which slows it to frequencies compatible with cost-efficient CMOS RAMs. **Fig 2**'s circuit clocks the two output registers at half the sample rate, and it latches data in each register 180x out of phase from the other. Some flash converters that operate in excess of 200 MHz have onboard demultiplexing for added convenience.

All that sparkles isn't gold

So far, these timing difficulties refer to how you deal with the converter's output data. But flash converters can have internal problems as well. Low input frequencies can cause comparator metastability, and



NOTE: WHEN V_2 < ANALOG INPUT < V_3, THE COMPARATOR OUTPUTS WILL BE AS SHOWN.

Fig 1—Flash converters contain a bank *of 2^N-1 comparators, where N is the number of output bits. Decoding logic transforms the comparator outputs into the appropriate N-bit result. Timing and input characteristics of the converter, such as mismatched comparator delays, mismatched ladder resistors, and nonlinear input capacitances, are just a few sources of converter errors.*

high input frequencies can lead to errors caused by slew-rate and delay mismatches. All of these errors may manifest themselves as sparkle codes in a poorly designed flash converter.

Sparkle codes are random errors whose magnitude may approach the full-scale range of the converter. The term refers to the white dots or "sparkles" that appear against a gray background when the ADC output drives a video display. There are two sources of sparkle codes: comparator metastable states and thermometer-code bubbles.

A comparator metastable state occurs if the comparator output falls between the logic-0 and logic-1 threshold of the digital decoding logic. If the threshold uncertainty region has a width of ΔV_L and the comparator has a gain of A, then the error probability P_m is a uniformly distributed value that's equal to

$$P_m = \frac{\Delta V_L}{Aq},$$

where q is the weight of the LSB.

A latched comparator in a flash converter has a regenerative gain of

$$A = A_0 e^{t/\tau}$$

when $t > 0$, and

$$A = A_0$$

when $t \leq 0$. τ equals the regeneration-time constant, and t is the time after the application of a latch command. The probability of a metastable state, P_m, for a regenerative comparator bank driving decoding logic is

$$P_m = \frac{\Delta V_L}{A_0 q} e^{-t/\tau}.$$

The magnitude of the sparkle code depends on the location of the metastable comparator in the comparator bank and on the logic-decoding scheme. For instance, the 128th comparator determines the MSB of an 8-bit flash converter with straight binary decoding logic. If this comparator's output is in a metastable state, the decoding logic may mistakenly convert the input voltage whose correct binary representation is 01111111 to 11111111, producing a full-scale error. If the comparator bank's thermometer-code output is first decoded into Gray code, latched, and then converted into binary code, the metastable error is reduced to 1 LSB, regardless of the comparator in error. Flash converters, however, rarely use this scheme because of the ripple-through time and the increased logic density of the Gray-to-binary circuitry. Instead, converter designers often use "pseudo-Gray" decoding techniques to eliminate the delay time associated with traditional Gray-to-binary circuits.

Note that the probability of a metastable-state error increases as the time-after-latch, t, decreases (assum-

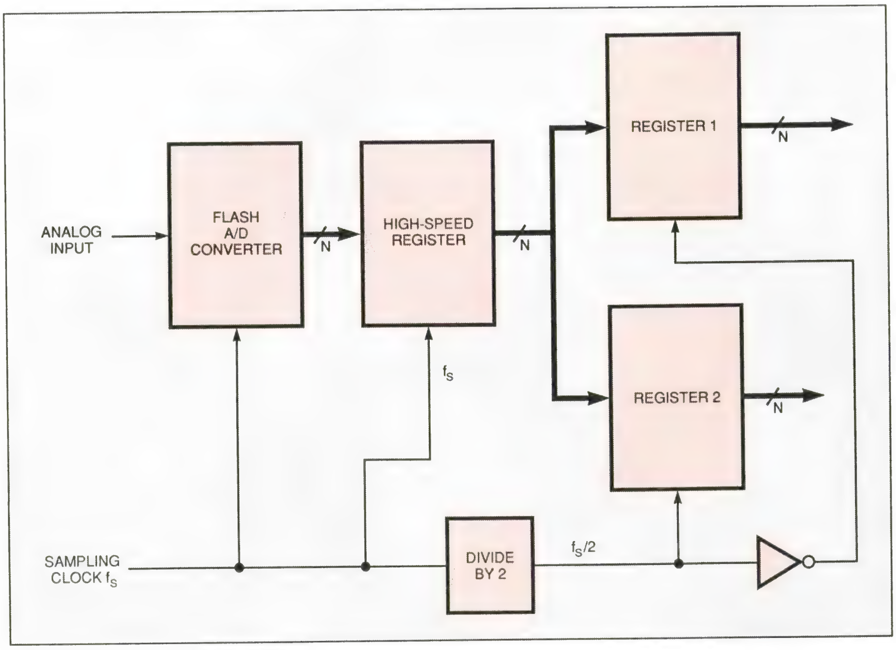
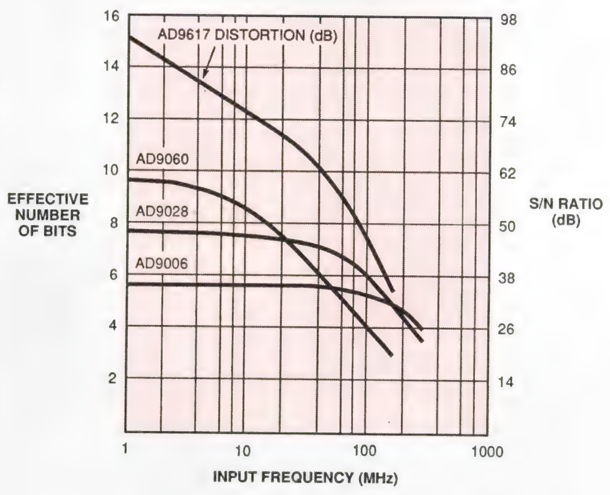


***Fig 2—Flash converters can operate** at extremely high sample rates. Thus, you must have an output register that can handle this fast data. By demultiplexing the converter's outputs, you can slow the data to a rate that's compatible with standard CMOS memory.*

One of the first difficulties you'll encounter when using flash converters is removing valid data from the converter.

ing a constant value of τ). This implies that the flash converter is more apt to produce metastable-state errors as you increase the sampling rate, because t must decrease correspondingly. Most manufacturers reduce metastable comparator states by minimizing the regeneration-time constant, τ. Lower regeneration-time constants result in higher power dissipation, which is one reason why many high-speed flash converters are power-hungry devices.

Thermometer-code bubbles are another potential source of sparkle codes. A well-behaved flash converter's comparator bank produces a specific sequence of ones up to a certain point in the input range of the converter, and it produces a sequence of zeros beyond that point. The decoding logic then assigns a binary number to the thermometer code. For low-frequency inputs, most flash converters' comparator banks are well behaved. At high speeds, however, delay mismatches among comparators may produce out-of-sequence ones and zeros in the thermometer code. The decoding logic then assigns an error binary code to these out-of-sequence points, or bubbles, which also result in sparkle codes. Again, proper comparator design and more sophisticated decoding-logic circuitry within the ADC itself can reduce these errors to acceptable levels.



FLASH ADC	RESOLUTION (BITS)	MAXIMUM SAMPLING RATE (M SAMPLES/SEC)	TEST SAMPLING RATE (M SAMPLES/SEC)
AD9060	10	75	60
AD9028	8	300	250
AD9006	6	500	400

Fig 3—Theoretically, a flash converter should maintain its performance *across the full Nyquist bandwidth. But as the curves in this figure illustrate, the S/N ratio starts to degrade well below each device's maximum sampling rate. (Note that these curves are based on test sampling rates that are somewhat lower than each device's maximum possible rate.)*

These comparator-timing errors degrade both the differential and integral linearity of a flash ADC as the input slew rate increases. In addition to static errors, such as missing codes and sparkle-code errors, slew-rate limitations manifest themselves as dynamic errors, such as increased harmonic distortion and degradation in the S/N ratio. Ideally, a flash converter should maintain its static performance specifications across the full Nyquist bandwidth, and certain applications demand full performance beyond the Nyquist bandwidth. The theoretical, rms S/N ratio for an N-bit ADC is given by the well-known equation

$$S/N\ ratio = 6.02N + 1.76\ dB.$$

However, as shown in a typical plot of S/N ratio versus input frequency for actual flash converters (**Fig 3**), the S/N ratio degrades as the input frequency increases. This degradation starts well below these converters' maximum sampling rates. The left vertical axis of **Fig 3** shows the S/N ratio in another term: effective number of bits. The effective number of bits is simply the value of N when you solve the above equation using a specific value for the S/N ratio. Aperture jitter (sample-to-sample variations in the effective-sampling instant) can also cause degradation in the overall S/N ratio for high-slew-rate inputs. Jitter can be internal or external to the converter. Part 3 of this series will cover this topic in more detail. To minimize externally produced jitter components, you should always practice proper grounding, power-supply-decoupling, and pc-board-layout techniques.

Watch for dangerous data-sheet territory

Most of the timing difficulties and error sources discussed so far are common to all flash converters. However, each converter features its own unique design and specifications; thus the data sheets require scrutiny. Don't be fooled into believing that sampling rate and input bandwidth are interchangeable; they're different specifications. It wasn't until recently that you'd even find input bandwidth specified for an ADC. Even now, no accepted industry-wide definition exists for a flash converter's full-power-bandwidth specification. Scrutinize the data sheet carefully and make sure you understand the manufacturer's definition and test method. The full-power bandwidth of a traditional op amp is the maximum frequency at which the amplifier can produce the specified p-p output voltage at a specified level of distortion. Another commonly used definition calculates the full-power bandwidth by dividing the amplifier's slew rate by $2\pi V_O$, where the output-voltage range of the amplifier is $\pm V_O$.

When you apply traditional analog-bandwidth definitions to flash converters, the results can be misleading. The dynamic-error sources previously discussed may become predominant long before the comparator front end approaches its maximum bandwidth. If you use a common definition of full-power bandwidth as the frequency at which the p-p reconstructed-sine-wave output is reduced by 3 dB for a full-scale input, then the effective number of bits (S/N ratio) at this input frequency may render the flash converter useless in your system. Thus, to get a true idea of a converter's performance, you must consider both the full-power bandwidth and the effective number of bits (S/N ratio) at a specific sampling rate.

Another definition you'll encounter occasionally for full-power bandwidth is the maximum, full-scale input signal at a specified sampling rate that produces no missing codes. Using this definition always gives the most pessimistic number, so specifications based on this definition appear on only a few data sheets. The following is a recently proposed definition for full-power bandwidth (courtesy Chris Manglesdorf, a senior scientist at Analog Devices): the frequency at which the fundamental component of the reconstructed FFT output—excluding harmonics—is reduced by 3 dB from full scale.

Just when you think you've mastered the intricacies of flash ADCs, you'll realize that you have another component to worry about: the input buffer amplifier. Fortunately (or unfortunately depending upon your perspective), the flash converter—not the amplifier—usually limits the converter's dynamic performance. A flash converter typically digitizes a signal from a 50, 75, or 93Ω bipolar or unipolar source. If the input range of the flash converter is incompatible with the signal, then you'll clearly need a wideband op amp to generate the required gain and offset (**Fig 4**). In addition, the input capacitance of some flash converters may vary as a function of the analog input's signal amplitude. Therefore, so that the nonlinear capacitance doesn't produce undesirable harmonics in the digitized signal, you'll need to use a buffer amplifier for isolation. For certain flash converters, the input capacitance is so high that a buffer amplifier is needed just to preserve the signal bandwidth.

A good choice for the buffer is a high-speed transimpedance amplifier. These amplifiers have high bandwidths and flat frequency responses over a broad range of input frequencies. Also, many transimpedance amplifiers exhibit extremely low distortion. Pairing the right amplifier with your converter is important. For instance, **Fig 3** shows the S/N ratio of various converters plotted along with the harmonic distortion of the AD9617. Since the THD of the amplifier is better than the S/N ratio of the converters, the amplifier won't degrade the flash converters' performance over the major portion of their usable bandwidth.

Another factor to consider when driving the input of flash converters is the input-signal polarity. Positive input signals, which forward bias the substrate diode, can damage a converter that has a unipolar, negative input-voltage range. Installing an external Schottky diode provides effective protection.

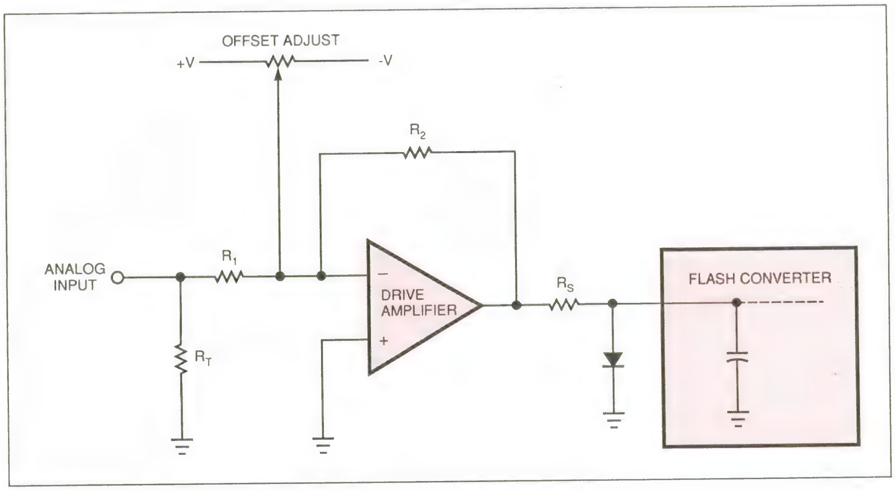


Fig 4—If the voltage range of the analog signal *and the input range of the ADC aren't compatible, you'll have to adjust the gain using R_1 and R_2 and also adjust the input signal's offset. Because of the substantial value and the often nonlinear nature of a flash converter's input capacitance, you must choose an appropriate drive amplifier and value for R_S.*

Ideally, a flash converter should maintain its static-performance specifications across the full Nyquist bandwidth, but in reality ADCs fall far short of this ideal.

The flash converter's input capacitance and the drive amplifier's isolation resistor, R_S, form a lowpass filter. Typical series-resistor and input-capacitance values of 10Ω and 20 pF create a single-pole lowpass filter that has a bandwidth of 800 MHz. However, if the input capacitance changes from 20 to 15 pF over the input range of the converter, then an attenuation error of 1.4% occurs for a 50-MHz input signal. This 1.4% nonlinearity will produce 37 dBc of harmonics. (The unit dBc refers to the number of dB between the signal you're measuring and the carrier frequency). If you minimize the value of R_S and still maintain op-amp stability, you can reduce the attenuation error caused by these lowpass filtering effects. The signal dependence of input capacitance is rarely specified, but as converters move toward higher bandwidths, you can expect to see this parameter on more data sheets.

Few, if any, flash converters contain an internal voltage reference, so in addition to an external drive amplifier, you must also design your own voltage-reference generator. **Fig 5** illustrates a typical −2V, unipolar reference-voltage circuit for a flash converter. A buffer transistor is necessary because the resistance of the converter's ladder string is usually fairly low. The total reference-ladder resistance of a flash converter depends heavily on the fabrication process and may vary considerably from device to device. Also, the ladder's resistance may exhibit a large temperature coefficient.

If the flash converter allows bipolar operation, then you'll have to generate two reference voltages. The circuit in **Fig 6** allows great flexibility in setting both the gain and the offset of a bipolar flash converter, and it operates on ±5V power supplies. A few flash converters provide a sense pin for the voltage reference. You can use this pin to compensate for the voltage drop caused by the package's pin and bond-wire resistances, as shown in the bipolar-reference circuit in **Fig 6**. In addition, some ADCs give you access to one or more taps along the internal, reference-ladder resistor string. To achieve better integral linearity, you can drive these taps from low-impedance sources.

Improve dynamics with T/H amplifiers

As previously discussed, the effective-sample time-delay variations among the latched comparators degrade the S/N ratio and the harmonic performance. You can visualize the individual comparators within an array as having variable delay lines in series with their latch-strobe inputs. To understand the effect of this delay on performance, consider an 8-bit, 100M-sample/sec flash converter that's digitizing a full-scale, 50-MHz sine-wave input. You can express the sine wave as

$$v(t)=V_P\sin 2\pi ft.$$

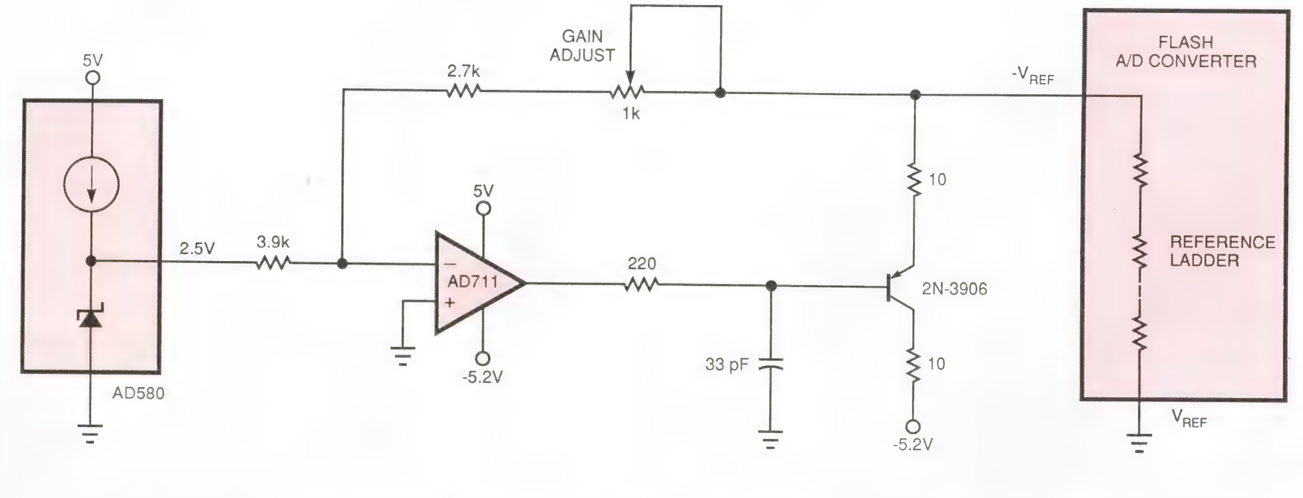


Fig 5—Flash converters don't have internal references, *so you must design them externally. This particular circuit provides a stable −2V reference for a unipolar converter.*

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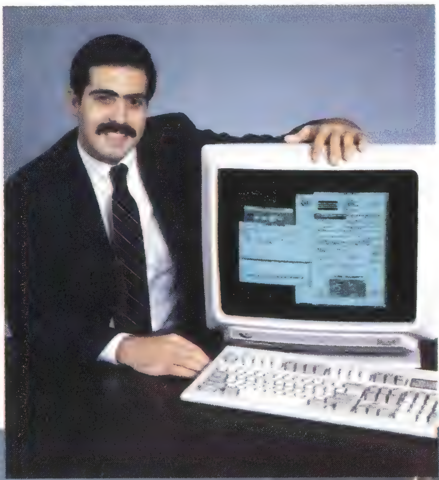

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To improve flash-converter performance at sampling rates as high as 25 MHz, you can use front-end T/H amplifiers to implement a "track-and-slow-down" approach.

The maximum rate-of-change of this signal occurs at the zero-crossing point and is equal to

$$\left.\frac{dv}{dt}\right|_{max} = 2\pi f V_P = \left.\frac{\Delta v}{\Delta t}\right|_{max}.$$

By solving this equation for Δt_{max}, you obtain

$$\Delta t_{max} = \frac{\Delta V}{2\pi f V_P}.$$

If the input-voltage range of the flash converter is 2V, or $V_P = 1V$, then the LSB weight is 8 mV for an 8-bit ADC. For the flash converter's error to be less than 1 LSB, Δt_{max} must equal 25 psec. The effective-sample delay mismatch between comparators can't exceed this value. If the mismatch is greater, a 50-MHz, full-scale sine-wave input will produce missing codes in the converter's output.

Placing an ideal track-and-hold (T/H) amplifier ahead of the flash converter theoretically would eliminate this problem, because the flash converter basically would be digitizing a dc input. In actual practice, T/H amplifiers aren't ideal, especially at high speeds. The signal presented to the flash converter is still changing, although at a slower rate. Nevertheless, this "track-and-slow-down" approach can improve the flash-converter performance at sampling rates as high as approximately 25 MHz. At sampling rates above 25 MHz, the T/H circuit needs to be mounted on the same substrate as the flash converter in a suitable hybrid package. Monolithic T/H amplifiers in hybrid packages with 8-bit flash converters have successfully achieved 7 effective bits at Nyquist inputs and at sampling rates of 250 MHz. These hybrid packages exact a penalty of higher cost and power consumption, however.

You'll find it difficult to select an appropriate discrete T/H amplifier, because the interaction between the T/H amplifier and the flash ADC is hard to predict. You should evaluate key T/H amplifier specifications such as acquisition time, full-power bandwidth, slew rate, and harmonic distortion. Harmonic-distortion specifications typically are provided for the track mode. The T/H amplifier's performance may be considerably

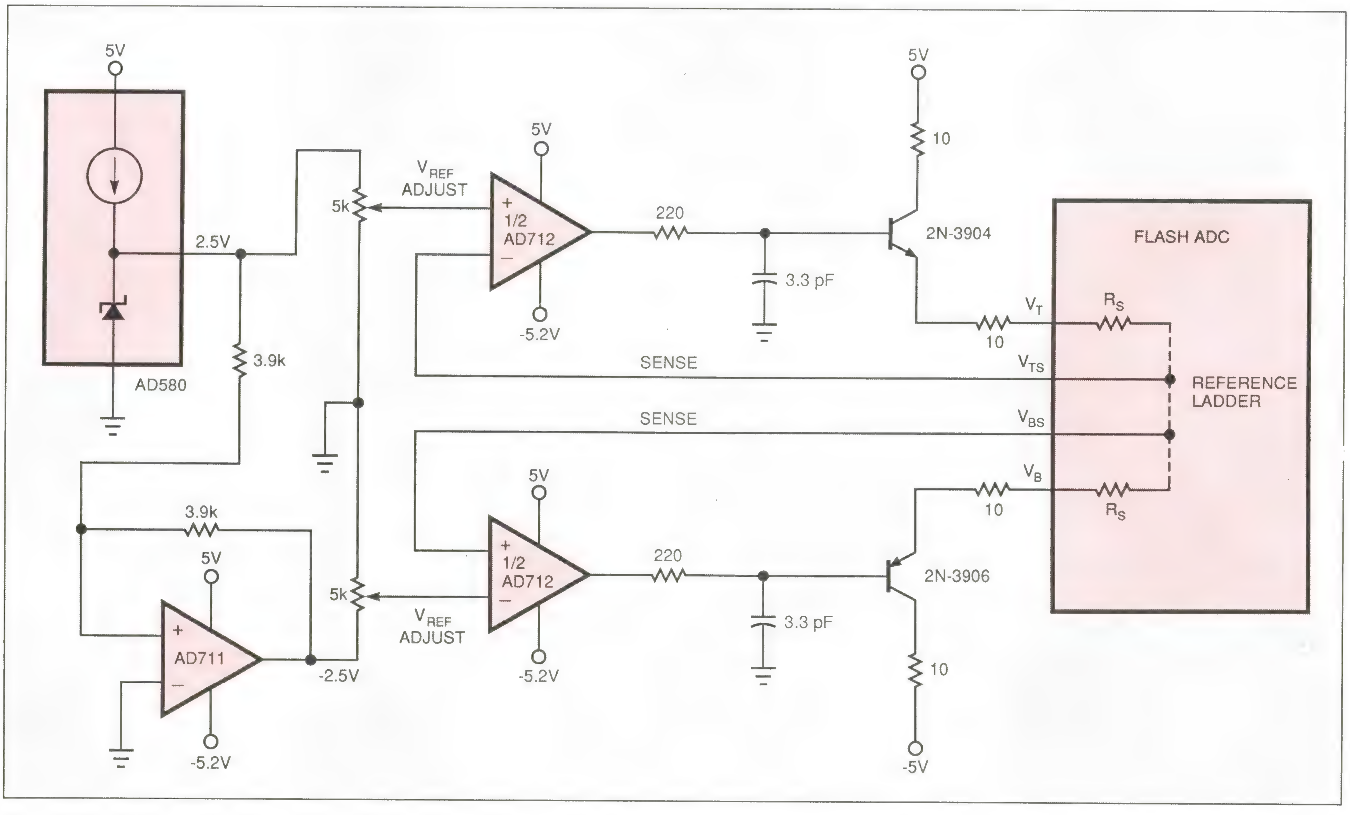

Fig 6—This reference generator *for a bipolar flash converter uses the sense pins provided by the resistor ladder to compensate for the voltage drops in the package's pin and bond-wire resistances.*

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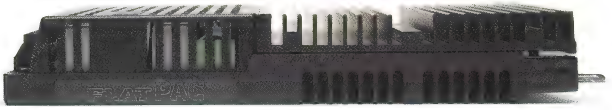

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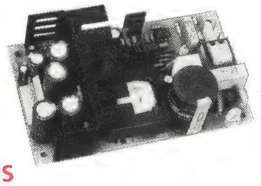

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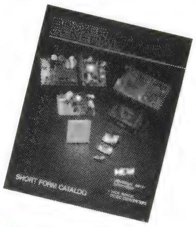

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CIRCLE NO. 67

worse than the stated specifications when the amplifier is in the hold mode and actually driving a flash converter. Also, the loading effects of the converter may degrade the T/H amplifier's performance. In addition, obtaining the optimum relationship between the various timing pulses that drive the T/H amplifier and the flash converter may require considerable experimentation.

Because of these many difficulties, the current goal of many ADC manufacturers is either to provide flash converters whose dynamic performance is acceptable without a T/H function, or to integrate the T/H function and converter on the same chip. In either case, manufacturers can fully specify the ADC for dynamic performance and spare you the somewhat difficult design problems associated with interfacing the T/H amplifier to the converter.

The knowledge of internal ADC features and the requirements these ADCs place on external circuits should guide your initial design efforts. But once you finish the design and build your circuit, you'll want to ensure that the combined performance of your converter and its support circuits meets your requirements. Part 2 will discuss various DSP-based test methods that are particularly effective in flash-converter testing. **EDN**

Reference

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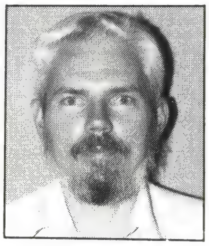
Author's biography



Walt Kester is a technical-support manager in the Computer Labs division at Analog Devices. Walt has been with the company for 20 years and has supported the development of high-speed ADCs, DACs, S/H amplifiers, and op amps. He has a BSEE from North Carolina State University and an MSEE from Duke University. In his spare time, Walt enjoys carpentry and travel.

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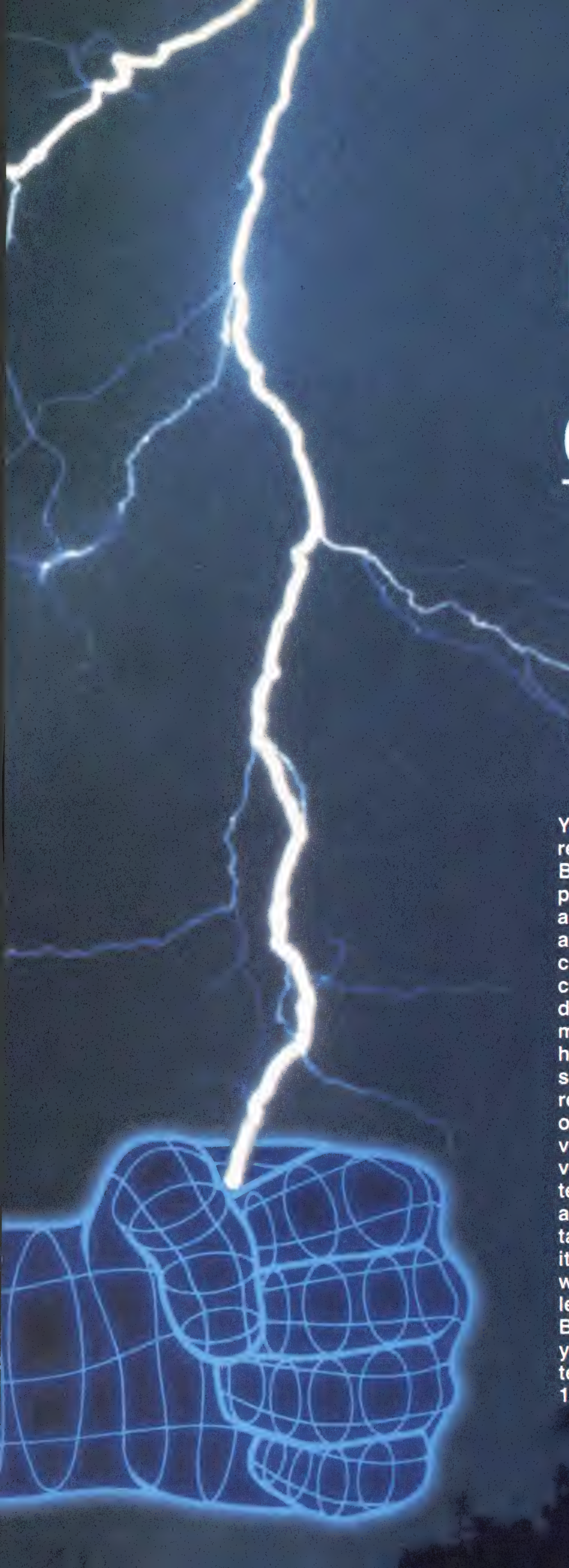

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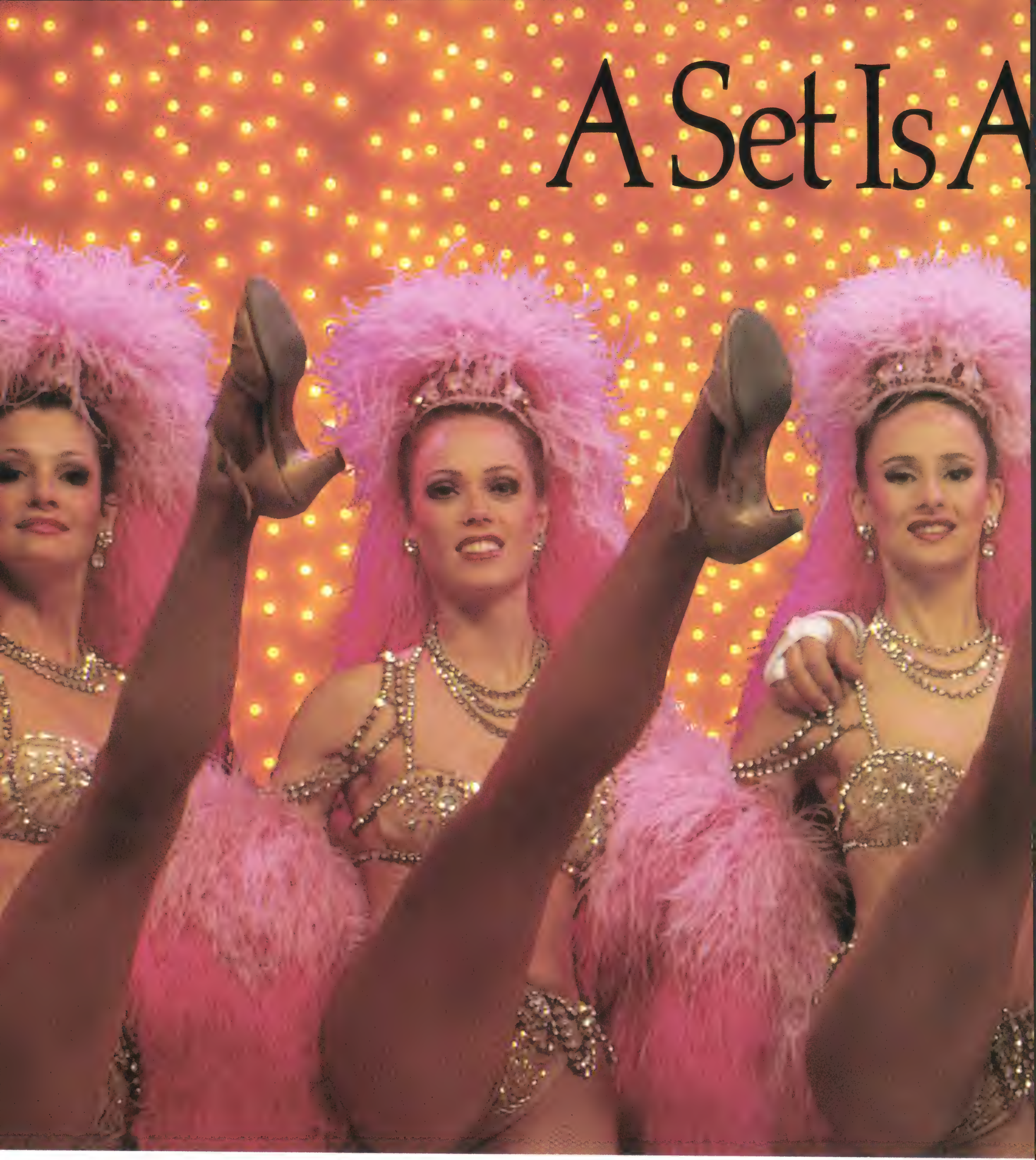

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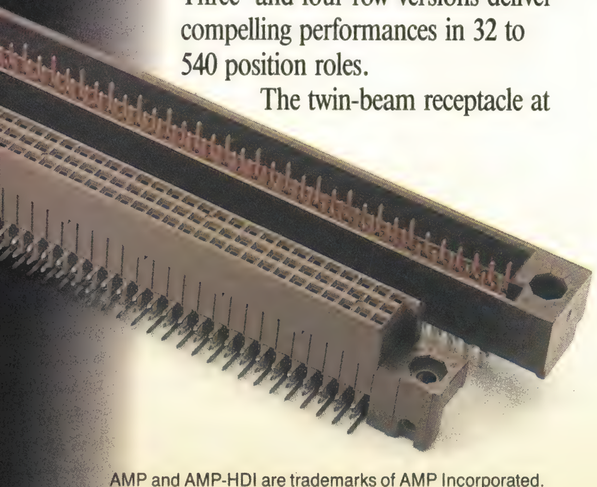

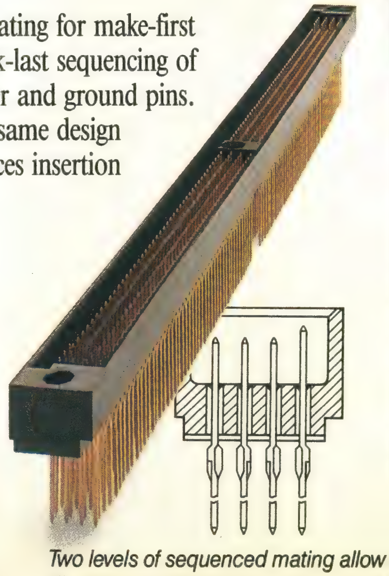

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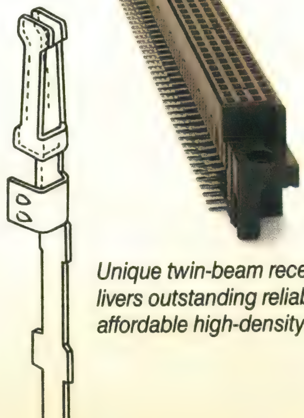

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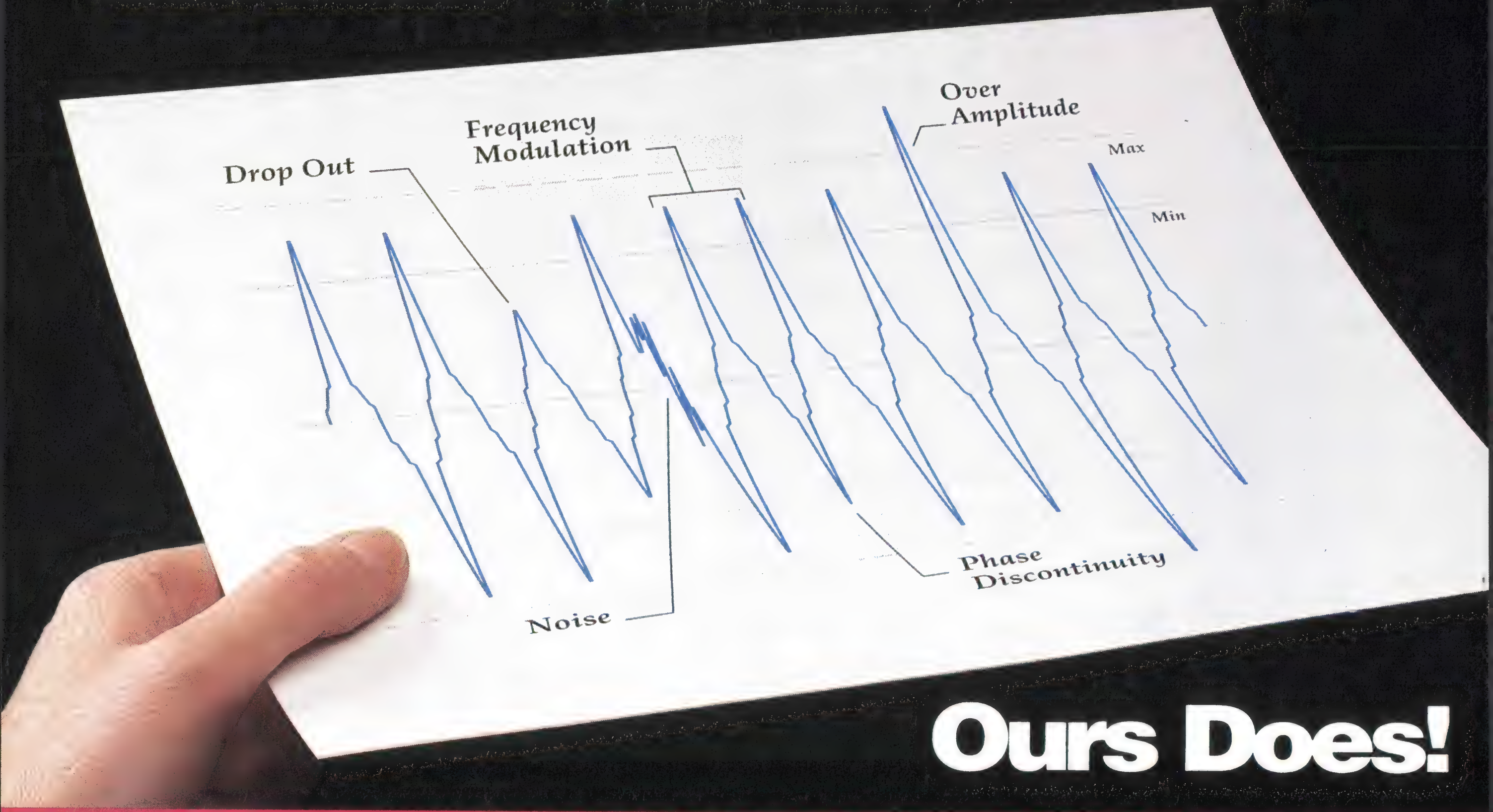

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GaAs technology holds promise for high-speed communications

Long-haul, point-to-point, and local-area-network (LAN) communications systems require data rates that are outstripping current silicon IC capabilities. However, manufacturers of GaAs ICs can now supply chips that will support high-speed data links.

Ronald M Hickling and Mark D Warlick,
Gigabit Logic

New high-speed long-haul, point-to-point, and LAN systems are rapidly emerging. Already 140M-bps and 565M-bps long-haul systems are in widespread use, and 1.2G-bps systems are under development. Europeans and Japanese are also developing new long-haul standards. Often these new systems are faster than the ones they're replacing by a factor of four. These dramatic advances in the standards for high-speed data links provide a good opportunity for designers to use GaAs technology.

Fig 1 is a diagram of a typical high-speed system. It's a fiber-optic trunk system that multiplexes and demultiplexes DS1 signals, which then interface with conventional copper cables. The system implements the 10G050 crosspoint switch, the 10G040A 8:1 time-division multiplexer, the 16G040/41 clock- and data-recovery circuit, and the 10G041A time-division demultiplexer. All of these devices are GaAs based.

Long-distance transmission systems that use copper cables or microwaves have achieved data rates as high as 140M bps, but these methods have become unattractive for two reasons. The random (kTB) noise makes transmission increasingly inefficient at high data rates due to the error-correction-coding overhead needed to minimize bit errors. Second, and more important, the cost per unit of capacity of fiber-optic transmission systems is substantially lower than these other media.

It is not yet clear if satellites are more cost effective than fiber for intercontinental voice communications, but it is clear that fiber is destined to replace all of the copper cable and most of the microwave long-haul communications systems for intracontinental use. However, the promise of the previously mentioned cost savings can only be realized if the full capacity of the fiber is used.

The emphasis is on faster LANs

Driven by the availability of large amounts of computing power in relatively inexpensive and compact packages, much of the emphasis in computer development has shifted from time-shared, mainframe computers to stand-alone personal computers and high-powered workstations. Such trends imply that in the future functions such as real-time graphics and scientific simulations will use centralized time-shared services less and less.

The result of this trend will be a need for faster

Fiber-optic systems are destined to replace all copper-cable-based systems and most microwave systems in long-haul communications for intracontinental use.

LANs to link stand-alone personal computers and workstations that are able to execute millions of instructions per second to the mainframe. Mainframes will still provide centralized data storage. Initially, such LANs have to be fast enough to transfer large volumes of information from local to central storage without significantly loading the mainframe. LANs will also have to transfer real-time graphics information from one station to another. Because digital video signals occupy a bandwidth in excess of 100M bps, uncompressed, gigabit-rate LANs will be needed within the next five years.

The three leading standards that formalize data transfer are Synchronous Optical NETwork (SONET), Fiber Data Distribution Interface (FDDI), and High Speed Channel (HSC). All are able to use GaAs-based components in their systems.

SONET is a unique long-haul or LAN fiber standard because it does not define architecture or hardware implementation—it only defines the data protocol. With SONET each system designer can develop a proprietary hardware architecture, usually implemented in ASIC technology, and that architecture can still interface with other SONET systems. The protocol allows data rates from 51.84M bps (OC-1) to 2.48832G bps (OC-48). This flexibility enables users to configure their communications systems for specific price and performance niches. SONET can be used in both long-haul and point-to-point systems. More importantly, SONET lets designers use higher data rates without changing the fundamental architecture or protocol of their systems. Moreover, the wide range of data rates allows the use of CMOS, ECL, and GaAs technologies, either individually or intermixed.

FDDI was the first standard to use fiber technology for LANs. However, many people discovered that the bandwidth of the fiber or silicon ECL technology was not seriously challenged by using 4B/5B data encoding at the specified 100M-bps data rate and the 125-MHz clock frequency. In systems using ECL, designers have to pay a power penalty. Other implementations employ oversampling techniques, which necessitate the use of GaAs ASICs for sufficient design margin.

Now that the initial silicon-based systems are in operation, system designers are considering using the FDDI protocol at the 1G-bps data rate. GaAs also provides an answer to the problem of providing these system upgrades. By using an oversampling technique for FDDI systems, you can achieve lower bit-error rates. Lower power implementations and the resulting lower system costs are also possible using GaAs.

HSC primarily supports high-speed data transfers commonly found in computer-to-computer links. Although intended for copper cable, HSC is also useful for fiber. The peak data rate of the HSC is selectable at 800M bps or 1.6G bps. Integrated Photonics Inc

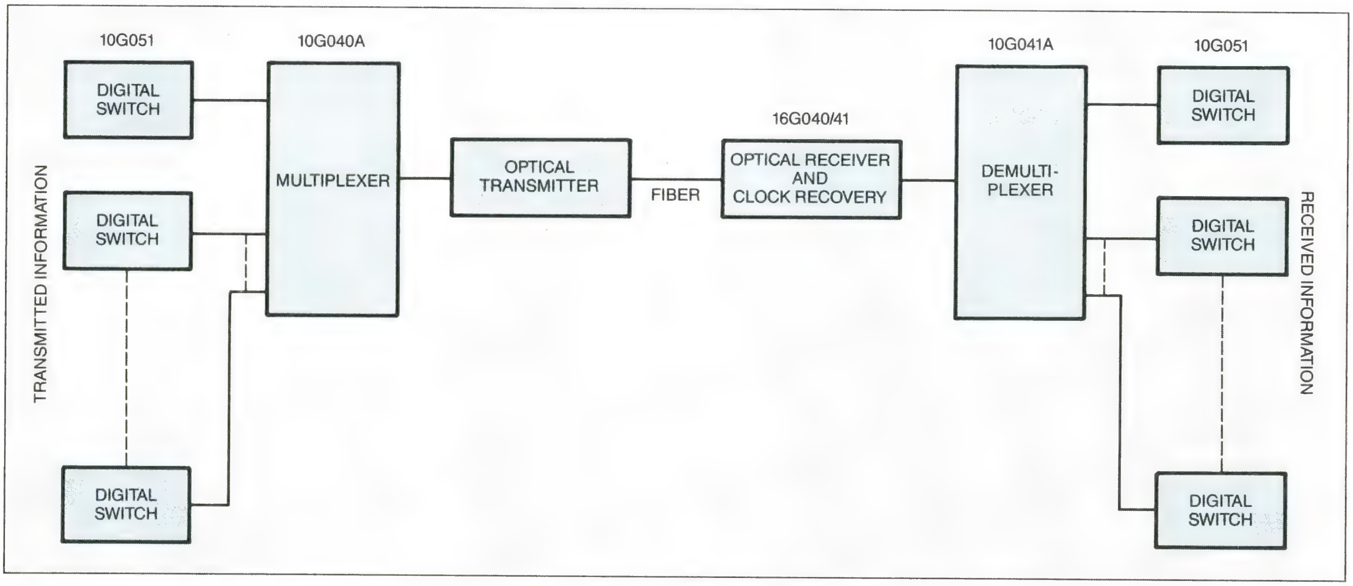

Fig 1—The typical fiber-optic trunk carrier *uses digital crosspoint switches, a time-division multiplexer, a clock- and data-recovery circuit, and a demultiplexer.*

(Carlsbad, CA) is the first company to develop commercial products that support the HSC standard.

LAN architectures vary

Designers can choose from four basic types of LANs. The star network requires separate circuits for each master-slave connection. The loop network connects all of the stations to a common data bus in a closed loop. The ring network also connects devices in a loop, but every station possesses knowledge of the protocol structure, which determines when a station can transmit. The topology of the bus network is an open-ended, common highway.

One of the challenges for the future will be to interface such LANs to the Integrated Services Digital Network (ISDN) and to one another. This challenge and the need for video bandwidth in the subscriber loop (such as digital television) will drive wide-area networks into the gigabit realm.

The building blocks of systems

Regardless of whether a data-communications system is used as a LAN, a wide-area network, or a long-haul system, and regardless of which standard is used, several functional building blocks are essential:

- Modem
- Scrambler/descrambler or encoder/decoder
- Multiplexer/demultiplexer
- Clock recovery circuit and data synchronizer
- Crosspoint switch.

Modems and clock recovery circuits and data synchronizers are either analog or mixed analog and digital. Scrambler/descramblers and encoder/decoders are strictly digital. Multiplexer/demultiplexers and crosspoint switches can be either analog or digital. Optical- or wavelength-division multiplexers and crosspoint switches are currently being used experimentally in fiber-optic communications systems. However, the complexity of these optical systems makes them impractical for widespread use right now. Because you can cascade them, time-division digital demultiplexers can realize almost limitless multiplex ratios. Wavelength-division multiplexers can only double the data rate. Optical crosspoint switches are plagued by optical losses. However, you can cascade digital crosspoint switches without losses, thus making these devices capable of handling extremely large switch matrices.

Although digital modulation techniques for microwave modulators vary, phase-shift keying (PSK) is quickly emerging as the most popular. The reason is PSK's inherent noise immunity and relative simplicity of design. The least complicated PSK modulator is the biphase shift keyer (BPSK), which is an exclusive-OR gate, such as the 10G002 (**Fig 2a**). You pass the carrier (or subcarrier if you are using frequency translation) through the modulator with or without a phase reversal in order to signify a mark or a space. Traditionally, designers have used double-balanced mixers for this function, but with the advent of today's high-speed exclusive-OR gate, the same function is possible without the conversion loss associated with mixers. Furthermore, the output of the 600-psec 10G002 exclusive-OR gate has a fixed amplitude, thus making the design of the amplifier or frequency chain following the modulator much simpler. **Fig 2b** shows a quadraphase shift keyer. This device combines two BPSK channels in phase quadrature, which lets you double the data rate. The associated demodulators appear in **Figs 3a** and **3b**.

Designers are continuing to explore phase-modulation techniques for fiber-optic communications. Currently, however, all commercially deployed systems use pulse-amplitude modulation, in which the light signal is simply turned on or off to signify a mark or

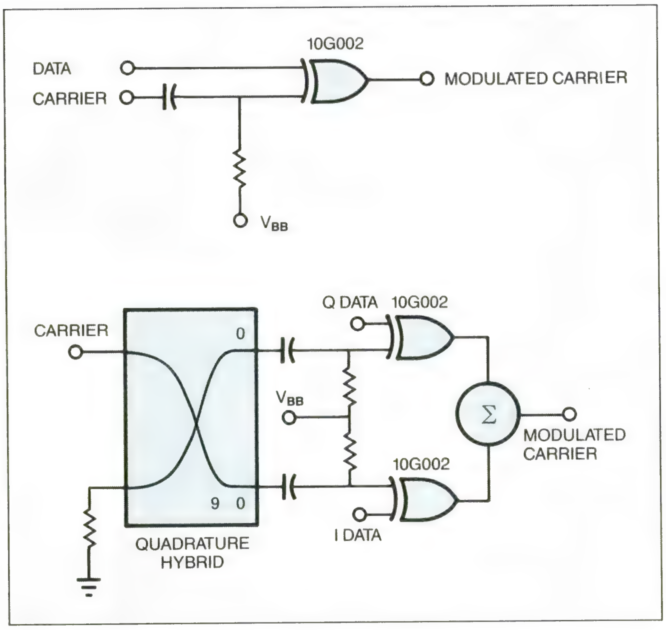

Fig 2—Phase-shift keying (PSK) is commonly used for microwave modulators. *The simplest PSK modulator* **(a)** *is the biphase shift keyer (BPSK). The quadraphase-shift keyer (QPSK)* **(b)** *combines two BPSK channels in phase quadrature, which allows a doubling of the data rate.*

SONET is a long-haul or LAN fiber-optic standard that defines the data protocol, but not the architecture or hardware implementation.

space. The differential laser-driver circuit of **Fig 4a** accomplishes pulse-amplitude modulation with the 16G075. Note that the bias-current input is feedback stabilized for constant light output to compensate for any effects (such as temperature) that might change the effective threshold current of the laser diode. Simpler circuits such as the 16G076 **(Fig 4b)** are used to drive LEDs. Although designers have also used TTL gates successfully to drive LEDs at low data rates, they often use complementary drivers such as the high-speed 10G012B **(Fig 4c)** in applications that require data rates of 100M bps and higher.

Scrambling and encoding techniques differ

When digital information is transmitted over a microwave or fiber-optic link, it's necessary to ensure that the data has sufficient 1-to-0 and 0-to-1 transitions from which the circuit can extract the timing information. These transitions are needed because there isn't any clock information embedded in an NRZ stream. Designers often use Manchester coding to eliminate this problem, but because it requires twice the normal transmission bandwidth, it's impractical for high-speed links. In addition, maintaining a balance between the number of 1s and 0s in a data stream is often necessary. This balance allows ac coupling, which vastly simplifies the analog modulation and demodulation circuits. It also ensures a constant signal power due to the consistent duty cycle.

Scrambling and encoding techniques provide both dc balance between 1s and 0s and adequate transitions from which a circuit can recover a clock signal. However, there are advantages and disadvantages to each technique. The primary advantage of the scrambling technique is that it doesn't add any data-rate overhead to a communications system. But descramblers are not capable of detecting or correcting errors and require special circuits to synchronize them. In addition, some serial data streams are rendered *less* random when passed through a scrambler. For these reasons, scramblers are best utilized on multiplexed versions of encoded signals and have some related transition characteristics.

On the other hand, you can design encoders to be as simple or as complex as the application demands. Block codes are particularly useful because you can implement the coding algorithm within a simple look-up table. You can also seek the optimum tradeoff between coding functionality and bandwidth overhead. For example, the popular 4B/5B coding scheme used in FDDI

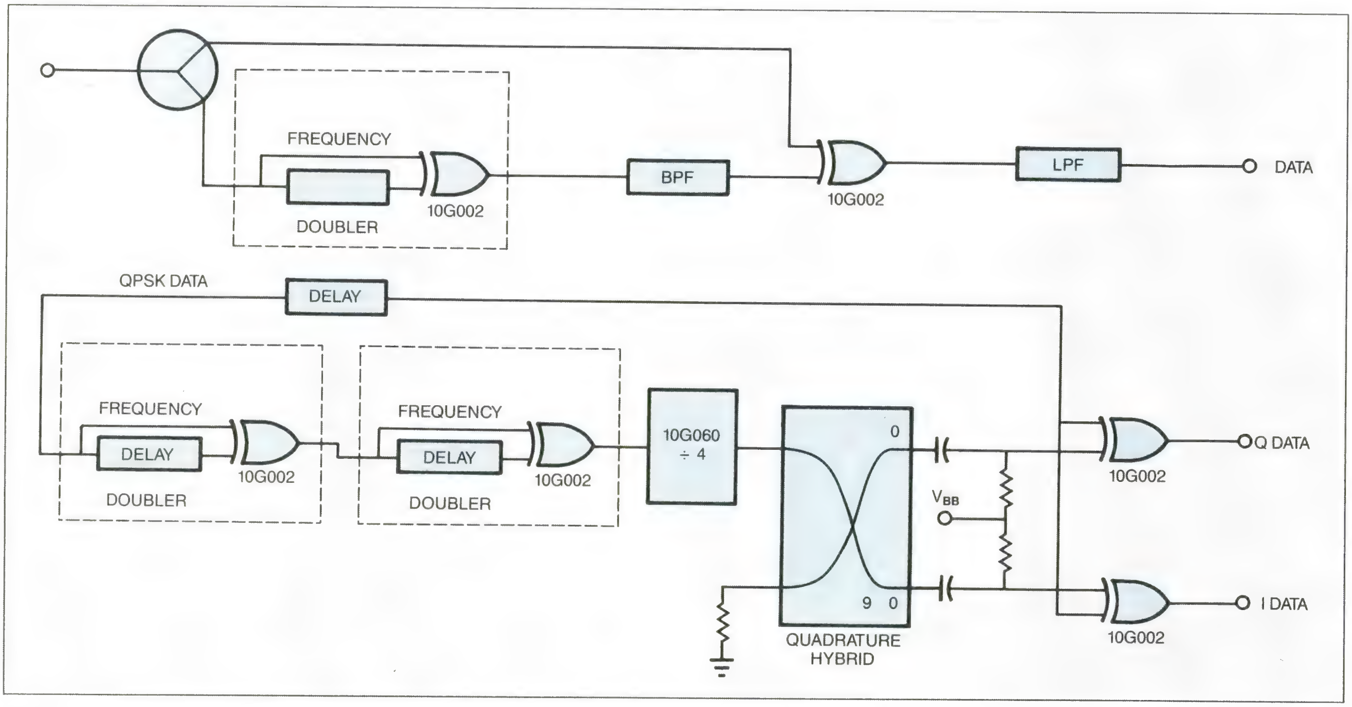

Fig 3—Complementing the modulator circuits *are a BPSK demodulator* **(a)**, *and a QPSK demodulator* **(b)**.

systems guarantees one transition in every five bits and can detect one error in every block (a loss in bandwidth of only 25%). In addition, the "illegal" codes can also double as special control codes.

For extremely noisy environments such as space communications, you can use forward error-correcting codes such as Golay, Bose-Chaudhuri-Hocquenghem (BCH), and Reed-Solomon codes. Although these codes are not specifically designed for dc balance or transition generation, you can choose an appropriate block length and code type to satisfy any transition or balance requirement. You can use the 14GM048, a 650-MHz 512×8-bit ROM, as a high-speed encoder and decoder. Several 1.5+ GHz registers are also available to implement the encoding and decoding functions.

Multiplexer and demultiplexer designs for long-haul network applications have been exceedingly simple, primarily because the implementation of the framing and elastic buffering functions are performed on the low-speed data stream. However, in LAN applications these functions are performed on the high-speed data stream. Therefore, the full implementation of the high-speed LAN multiplexer/demultiplexer scheme might resemble that of **Fig 5**, which utilizes a 1.45-GHz multiplexer/demultiplexer pair.

Clock recovery is complex

Perhaps a digital data receiver's most complex function is synchronizing clock signals to received analog pulses to convert those pulses into digital information.

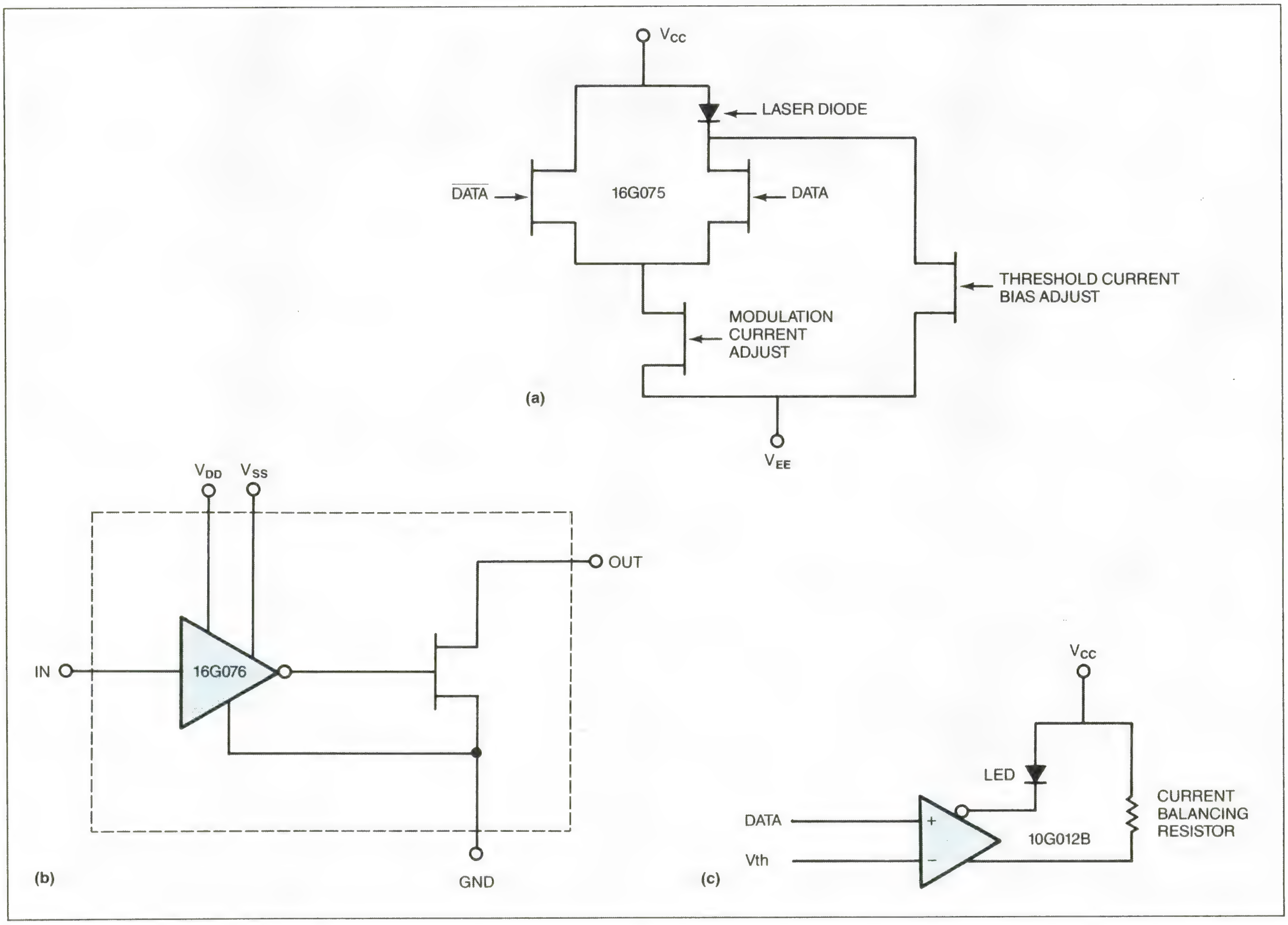

Fig 4—Commercially deployed fiber-optic systems use pulse-amplitude modulation to drive a laser diode. *In this circuit* **(a)**, *the light signal is simply turned on or off to signify a mark or space. Simpler circuits* **(b)** *are used to drive LEDs. The complementary LED driver* **(c)** *is useful at data rates of 100M bps.*

In the near future, LANs will be able to transfer real-time graphics information from one station to another at gigabit rates.

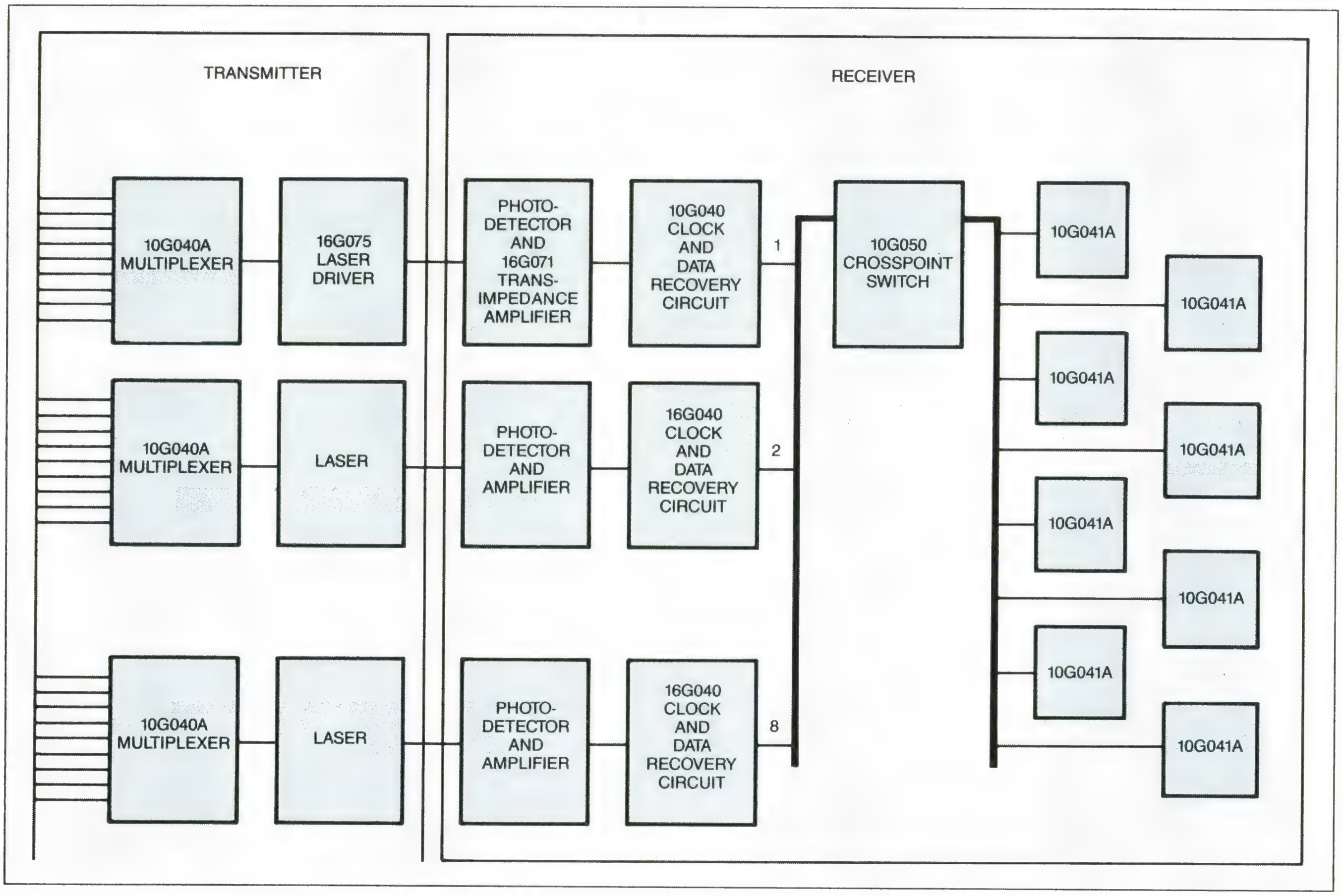
TRANSMITTER
RECEIVER
10G040A MULTIPLEXER
16G075 LASER DRIVER
PHOTO-DETECTOR AND 16G071 TRANS-IMPEDANCE AMPLIFIER
10G040 CLOCK AND DATA RECOVERY CIRCUIT
1
10G050 CROSSPOINT SWITCH
10G041A
10G040A MULTIPLEXER
LASER
PHOTO-DETECTOR AND AMPLIFIER
16G040 CLOCK AND DATA RECOVERY CIRCUIT
2
10G040A MULTIPLEXER
LASER
PHOTO-DETECTOR AND AMPLIFIER
16G040 CLOCK AND DATA RECOVERY CIRCUIT
8

Fig 5—The full implementation of a high-speed LAN *might resemble this scheme, which utilizes the 1.45-GHz 10G040A/10G041A multiplexer/demultiplexer pair.*

At low speeds you can use asynchronous oversampling for this task. Bit stuffing can make up any differences in the data rate between the receiver and the transmitter. This approach is relatively simple because both the transmitter and the receiver are generally crystal controlled and therefore minimally mismatched in frequency.

At high speeds, however, you can't use oversampling techniques because the high sampling frequencies required are impractical. For data rates less than 200M bps, you can use Manchester coding techniques. The Manchester code guarantees a transition during every bit period but occupies twice the bandwidth of normal NRZ data. At the highest data rates in use today, NRZ is the preferred method of transmission. Scrambling or encoding ensures an adequate number of transitions to provide the timing information.

Two basic methods exist for clock synchronization to an NRZ data stream. The first method involves passing the data through a nonlinear device, such as a doubler, then through a bandpass filter centered at the clock frequency **(Fig 6)**. This method, although simple, has several drawbacks. First, the phase delay through the clock-recovery path is prone to density-dependent transition variations due to amplitude-dependent variations in the AGC amplifer. Second, there may be a frequency-dependent group delay with high-Q filters. And third, temperature has a tendency to change all of these parameters, thus making the total variation in clock-path delay rather large.

The second method for clock synchronization to an NRZ data stream involves phase locking a VCO to the data stream with a sample-and-hold type of phase detector. The PLL approach is particularly eloquent because you can phase-lock an inexpensive, temperature-dependent VCO to a crystal-controlled transmitter

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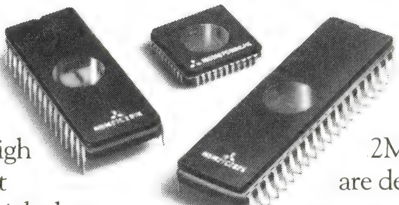

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One of the greatest future challenges to designers will be to interface high-speed LANs to ISDNs and to one another.

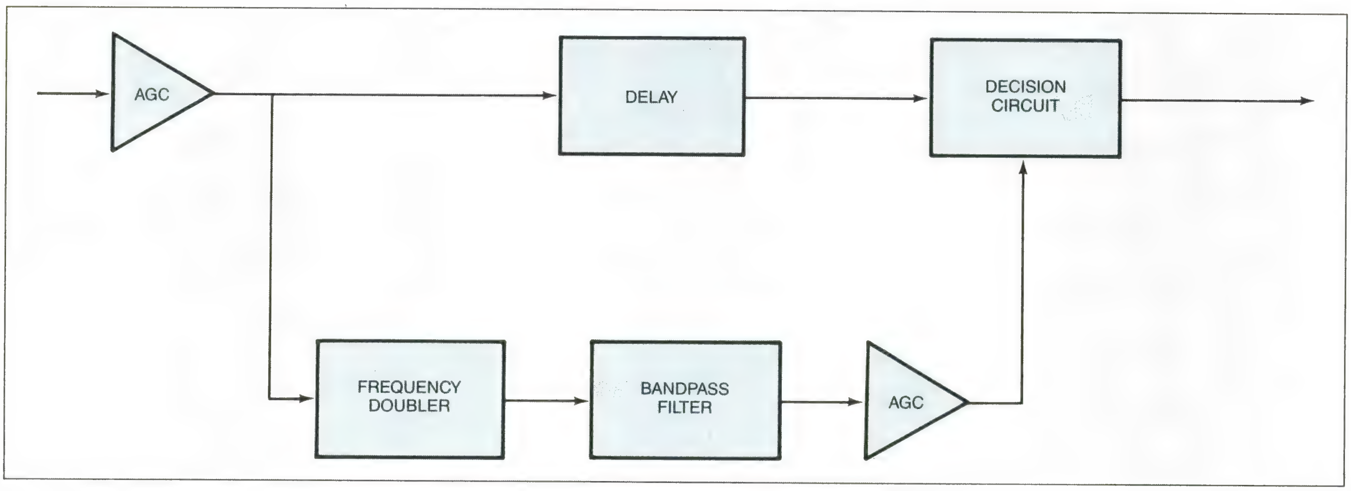


Fig 6—There are two basic methods for clock synchronization to an NRZ data stream. *One method, shown here, passes the data through a frequency doubler, then through a bandpass filter that is centered at the clock frequency.*

clock and obtain stable performance. In addition, by changing the loop-filter parameters, you can trade off one or more of the following: acquisition time, noise bandwidth, or output-jitter propagation.

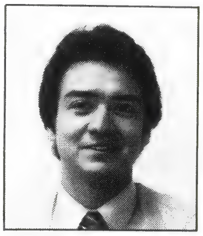
Don't overlook the crosspoint switch

Oddly enough, most manufacturers of high-performance silicon devices have overlooked the crosspoint switch. As a result, designers have used mature CMOS and ECL standard products, such as analog switches and multiplexers, to perform the function. Because these products had limited bandwidths, a second popular option was to use discrete 10K/100K logic or FAST logic. But this approach also has its drawbacks, such as high power dissipation and taking up excessive board space. Although fine-line CMOS crosspoint switches have recently become available, they are usually limited to a data rate of 50M bps. System speeds above 50M bps necessitate the use of either ECL and GaAs ASICs or a 16×16, expandable crosspoint switch, a 2G-bps data rate, and a 1.5-nsec reconfiguration time. High-speed, off-the-shelf crosspoint switches eliminate the nonrecurring engineering costs associated with ASIC development.

High-speed communications is entering an exciting new era. The availability of new GaAs-based standard products has allowed the quick implementation of gigabit-rate communications systems, both long-haul systems and LANs. The maturation of GaAs technology has enabled designers to create systems that were only in their imaginations just a few years ago. **EDN**

Authors' biographies

Mark D Warlick has been with GigaBit Logic for two years, initially as an applications engineer and now in the ASIC marketing group. He received his BSEE from San Francisco State University and his MS in manufacturing engineering from Boston University where he was a Graduate Engineering Minority Fellow. His current interests include 1950's jazz and basketball.



Ronald M Hickling has been with GigaBit Logic since 1983, where he is involved in the development of telecommunications products. He received his BSEE and MSEE from UCLA. A holder of two patents, Mr. Hickling is a member of the IEEE and Tau Beta Pi and is a fellow of the Institute for the Advancement of Engineering.

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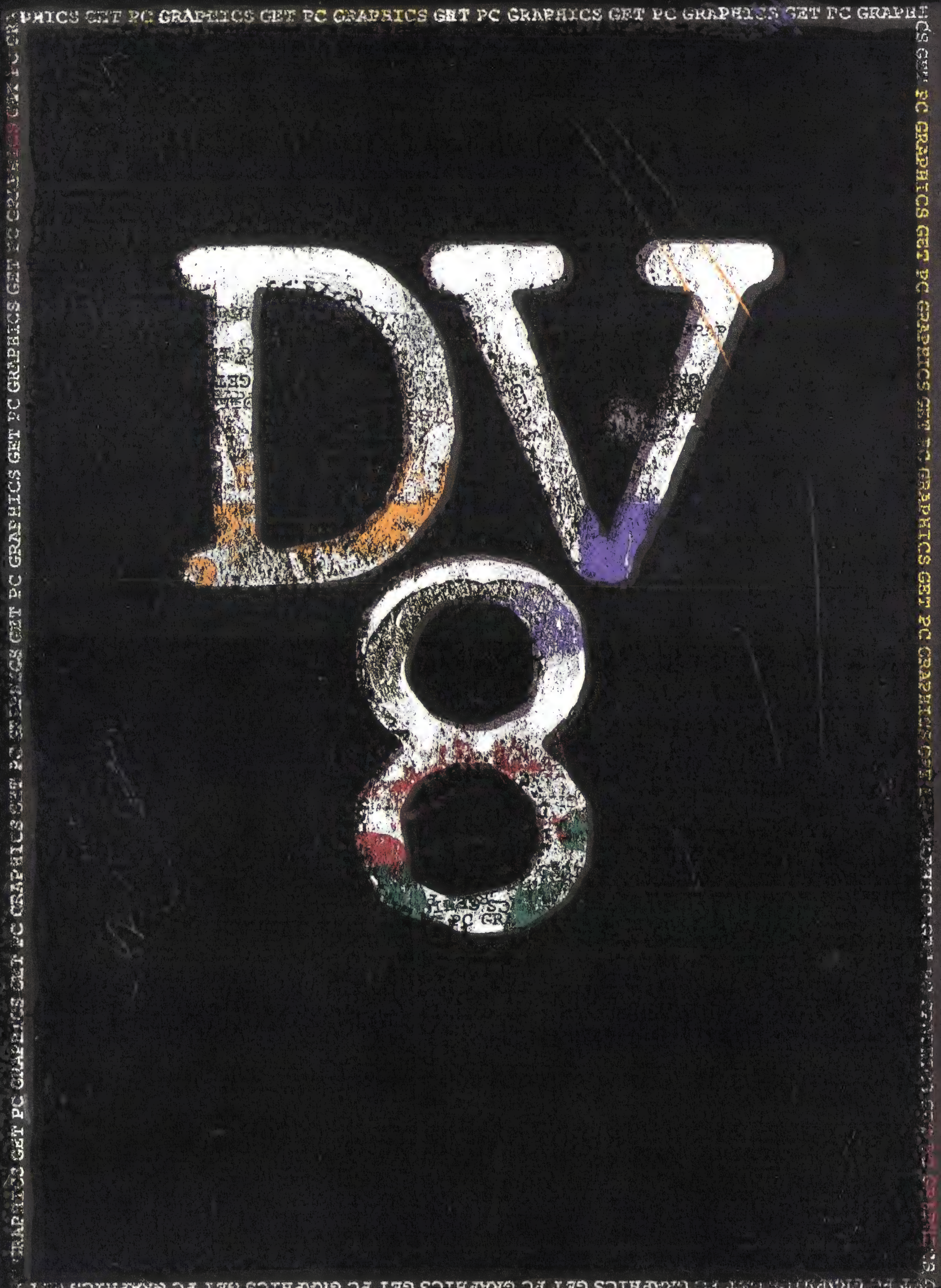
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Standards are made to be broken. And bettered. And built upon. At Brooktree, we've created a feature-laden, pin-compatible family of RAMDACs that enable graphics systems designers to do just that.

Brooktree is synonymous with high resolution color graphics. Now we've got the whizziest graphics chips alive for laptops, multi-window color, 8514A clones, true color and image capture.

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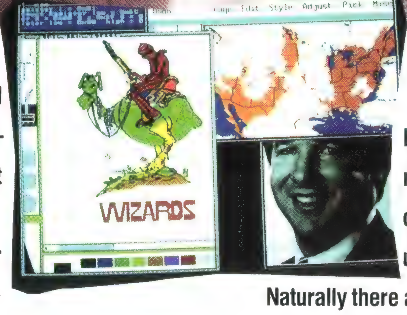
You can't control color in multiple windows unless you DV8

Oops! In the headlong rush toward windows environments, graphic-based applications and multitasking, color palette technology got left behind—almost.



Each window in a multi-tasking environment *can* control its own color palette—*if* you design in the Bt479.

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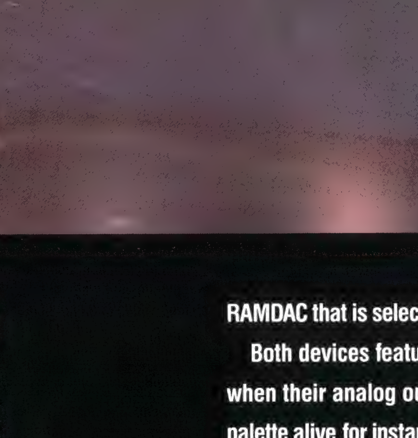

The on-chip voltage reference simplifies your design cycle, requiring just one external resistor to set the full-scale output current of the triple 8-bit DACs. And on-chip comparators verify proper connection of the CRT.

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Brooktree is defining the future of Neat Visual Stuff, on the back end for presentation purposes, and on the front end for image capture, too.

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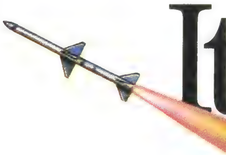

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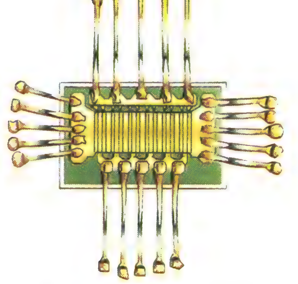

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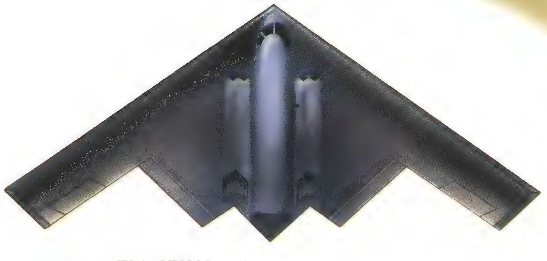

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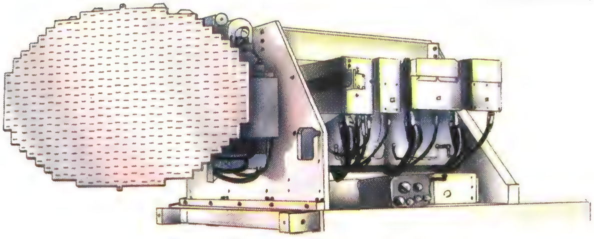

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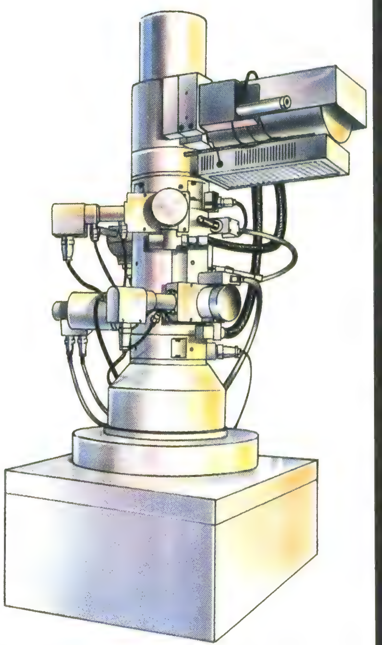

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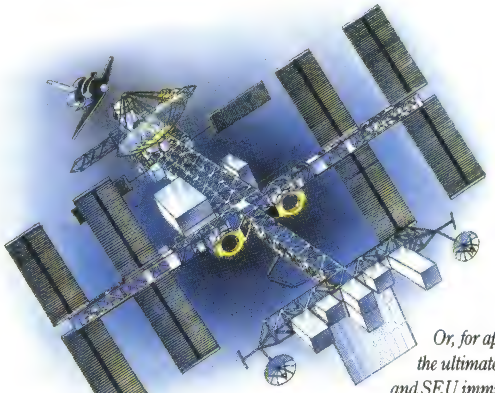

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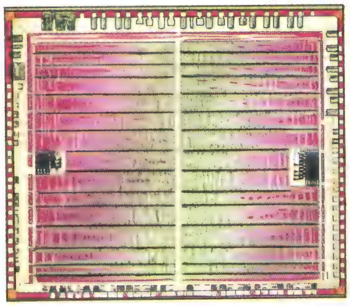

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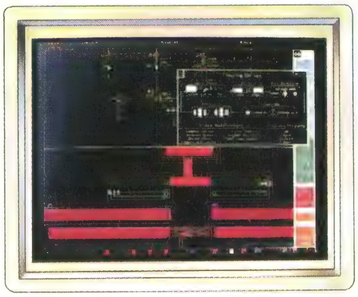
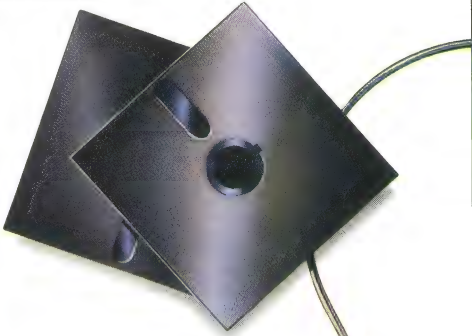
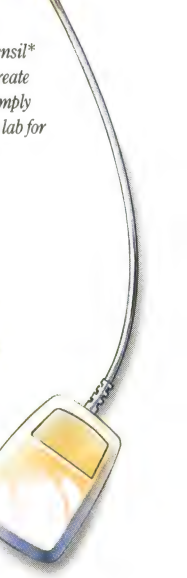




Harris' support of Silicon Compiler System's Gensil and GDT* programs let you create the most complex IC designs simply and easily. And we're a qualified lab for Silicon Compiler Systems.*



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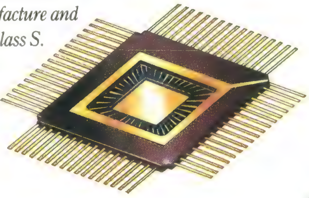
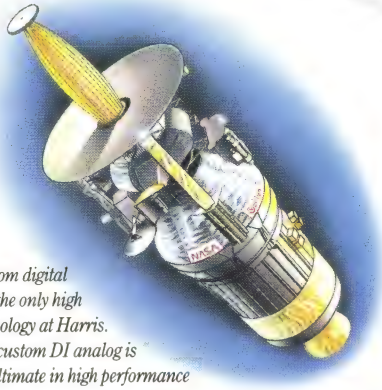
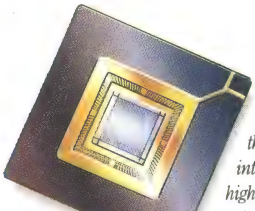




Custom digital isn't the only high technology at Harris. Our custom DI analog is the ultimate in high performance for analog design, including high-speed op amps with slew rates to 1000 µV/sec.



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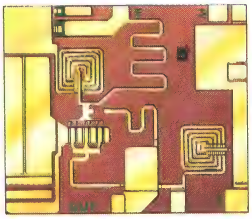

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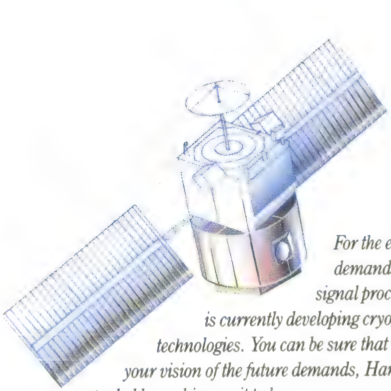

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CIRCLE NO. 75

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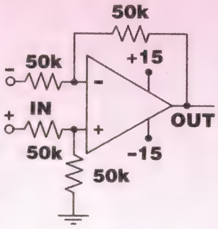
LT1097. Low cost. Low power. Precision OpAmp.

±27V COMMON MODE RANGE DIFFERENCE AMP
GUARANTEED PERFORMANCE V_S = ±15V, T_A = 25°C

PARAMETER/(UNITS)	LT1097 CN8	OP77 GP	AD707 KN	OP177 GP	OP97 FP
ERROR TERMS (μV)					
Vos MAX	50	100	90	60	75
Ios MAX x 25kΩ	6	70	50	70	4
MIN Gain 10V out	14	5	3	5	50
MIN CMRR ±25V in	22	20	13	22	39
MIN PSRR Vs = ±15V ±10%	6	9	9	9	9
SUM OF ALL ERROR TERMS (μV)	**98**	**204**	**165**	**166**	**177**
0.1Hz to 10Hz NOISE (μVp-p)					
Voltage Noise	0.50	0.38	0.23	0.38	0.50
Current Noise x 50kΩ	0.11	0.75	0.70	0.75	0.10
Resistor Noise	0.55	0.55	0.55	0.55	0.55
RMS SUM (μVp-p)	**0.75**	**1.00**	**0.92**	**1.00**	**0.75**
DRIFT WITH TEMP (μV/°C)					
MAX TCVos	1.0	1.2	1.0	1.2	2.0
MAX TCIos x 25kΩ	0.1	2.1	1.0	2.1	0.2
SUM OF DRIFT TERMS (μV/°C)	**1.1**	**3.3**	**2.0**	**3.3**	**2.2**
MAX SUPPLY CURRENT (μA)	**560**	**2000**	**3000**	**2000**	**600**
PRICE, Thousands	97¢	MORE	MORE	SAME	MUCH MORE



Linear's new LT1097 sets a new standard in low price, low power precision performance. It has only one grade—**precision.** And only one price—**97¢ in thousands.** The front page specs on most op amp datasheets are for the highly selected expensive grades. The specs for their low cost parts are **buried** deep in the datasheet. The LT1097 provides a max offset voltage of 50μV, picoampere bias and offset currents at 560μA max supply current. The performance of the difference amplifier as outlined in the table illustrates why the LT1097 is the ideal replacement for the OP77, AD707, OP177 and OP97—**lower total errors, lower noise, lower drift, lower supply current—all at a lower price.** For improved price/performance take a hard look at Linear's new LT1097 op amp.

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CIRCLE NO. 76

DESIGN IDEAS

EDITED BY ANNE WATSON SWAGER

RS-232C lines drive CMOS circuits

Gerald E Grady
Maxim Integrated Products, Sunnyvale, CA

The circuit in **Fig 1** illustrates a way to power CMOS ICs from RS-232C lines. The MAX680 is normally used to generate a voltage equal to $\pm 2 \times V_{CC}$. This circuit does exactly the opposite. It takes in ±10.5 to ±12V on the DTR and TD lines and puts out a 5.25 to 6V signal. A pair of Schottky or silicon diodes rectifies each RS-232C line. The resultant energy is stored by the capacitors attached to the IC's V^+ and V^- pins. C_1 or both C_1 and C_2 then reverse charge pump the energy stored at the V^+ and V^- pins to C_3. The input source current of the MAX680 is approximately equal to the voltage drop of any one of the diodes divided by the series resistance of 160Ω. When you drive this circuit from a 1488 driver with a ±12V supply, it can deliver 5V at 3 mA.

To increase the output current, you can use as many as three sets of diodes on each RS-242 line to provide 5V at 8 mA (**Fig 2**). The more diodes you use, the lower the source resistance: R_S equals the inversion of the sum of the diodes' conductances. If your circuit requires even more output current, you can place two MAX680s in parallel, tie their V^+ and V^- capacitors together, and use separate C_1 and C_2 capacitors for each chip. If you do connect the devices in parallel, make sure not to exceed the power capability of the RS-232C lines.

To Vote For This Design, Circle No.747

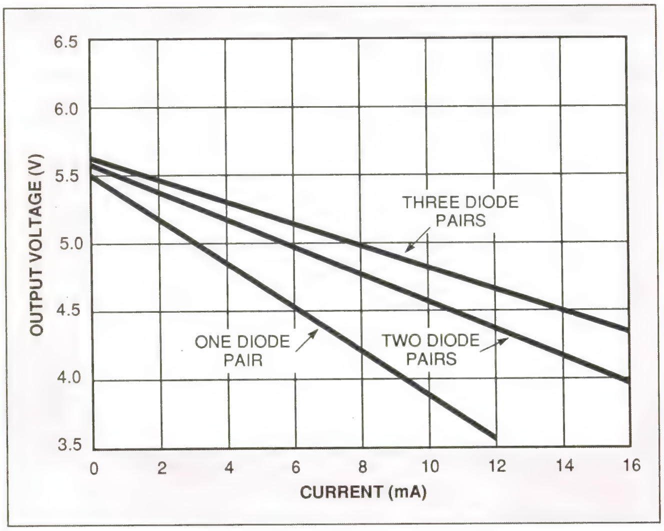

*Fig 2—**With one pair of diodes** on each RS-232C line, the circuit can supply 3 mA at 5V; with as many as three pairs of diodes, it can deliver 8 mA at 5V.*

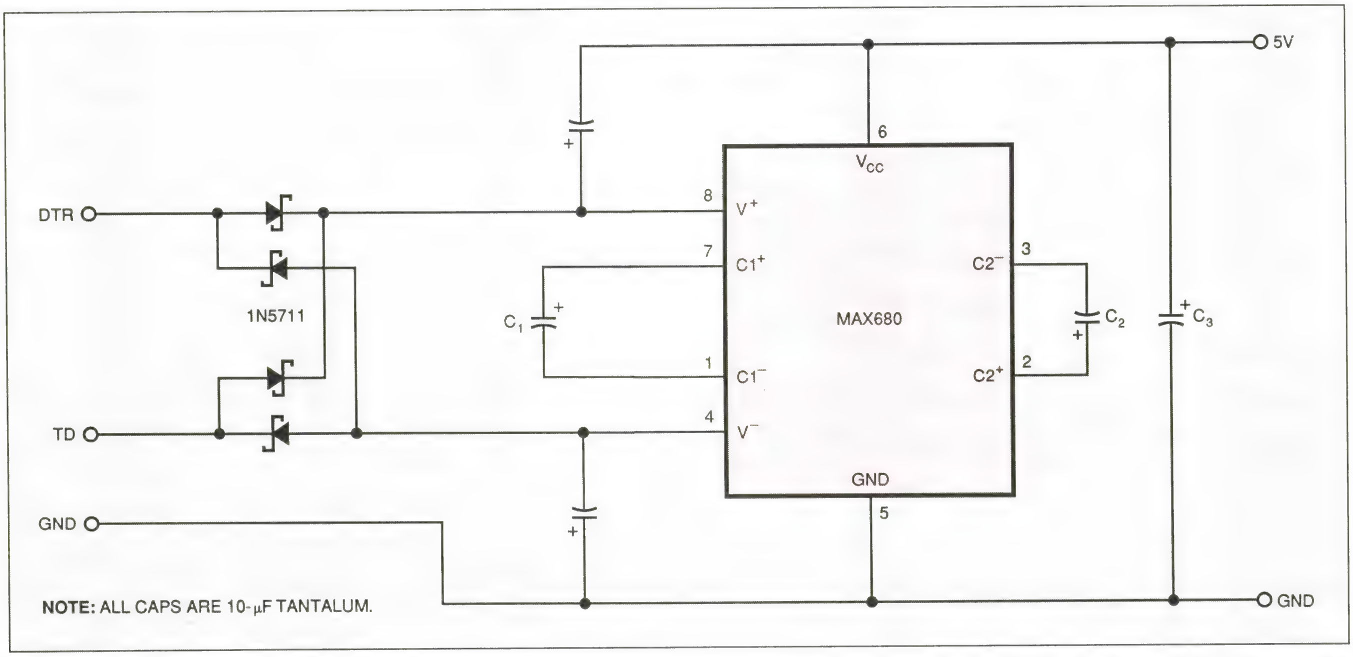

*Fig 1—**A pair of Schottky diodes** rectify the RS-232C signals, and the IC transfers the energy to its V_{CC} pin to provide 5V of power for CMOS circuits.*

Hysteresis stabilizes monotonic comparator

Terry Patterson
Research and Productivity Council,
Fredericton, New Brunswick, Canada

The circuit in **Fig 1** provides monotonic digital outputs that correspond to the various input ranges of a transducer. Specifically designed to drive solenoid valves and alarm contacts in a pressure control system, the circuit implements hysteresis to prevent the drive signals from turning the relays on and off repeatedly.

The ADC0803 A/D converter generates a digitized transducer signal, which forms the 8-bit address to the 2716 EPROM. The on and off states for the eight relays are determined by the eight bits you store in each EPROM cell. For example, if you want one relay to be on over a certain transducer signal range, all cells

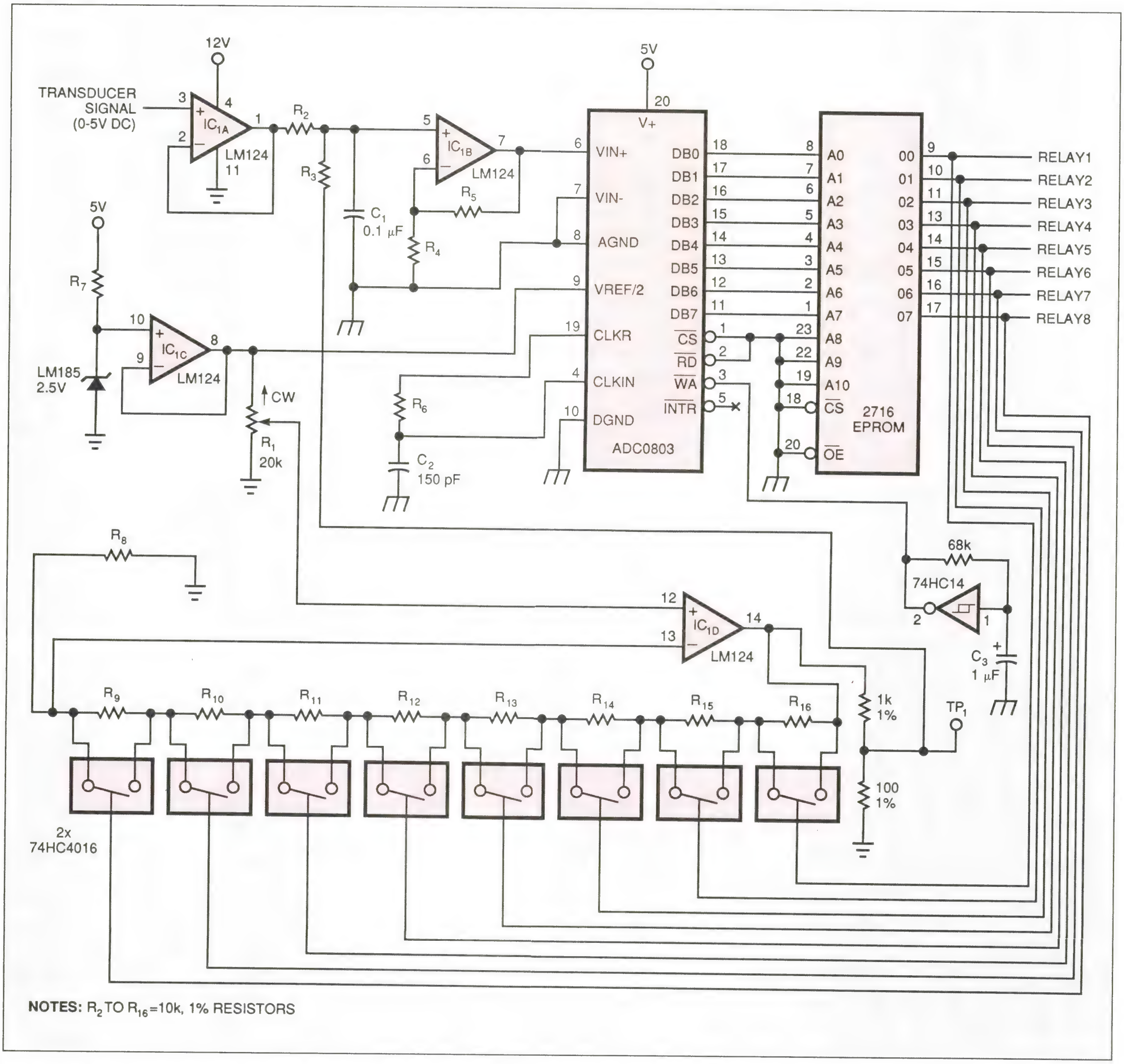

Fig 1—This monotonic comparator circuit *includes global hysteresis to prevent the destructive actuation of the relays.*

that the ADC addresses over that range should contain 11111110. In the example in **Fig 1**, the "0" value of the last bit causes one relay to turn on. When the input signal enters another range, the ADC addresses EPROM cells containing 11111100, thereby turning on two relays. You can program any pattern of outputs into the EPROM to provide any desired switch pattern in response to various input signals. A typical EPROM pattern is shown in **Table 1**.

To prevent the rapid and destructive repeated actuation of a relay or relays, **Fig 1** contains a hysteresis circuit. This circuit uses an adder, IC_{1B}, to bias the signal received from the transducer. Whenever the EPROM calls for a new relay output state, the feedback adds 39 mV, or 2 bits, to the input signal. This bias throws the ADC's input—and therefore the EPROM's memory location addressed by the ADC—further into the input range that corresponds to the new relay state, and thus prevents the relay from immediately returning to the previous state on the next conversion. When programming the EPROM cells, you must add 2 bits of hysteresis to the first set point, 4 bits to the second, 8 bits to the third, and so on. The amount of feedback is controlled by R_1. To set the hysteresis at 2 bits, make sure all of the outputs are in the off state (logic high) and adjust R_1 so that the voltage at TP_1 is 39 mV.

TABLE 1—EPROM CONTENTS

```
ADDR   0 1 2 3 4 5 6 7 8 9 A B C D E F
--------------------------------------------
:0000 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
:0010 FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
:0020 FEFEFEFEFEFEFEFEFEFEFEFEFEFEFEFE
:0030 FEFEFEFEFEFEFEFEFEFEFEFEFEFEFEFE
:0040 FCFCFCFCFCFCFCFCFCFCFCFCFCFCFCFC
:0050 FCFCFCFCFCFCFCFCFCFCFCFCFCFCFCFC
:0060 F8F8F8F8F8F8F8F8F8F8F8F8F8F8F8F8
:0070 F8F8F8F8F8F8F8F8F8F8F8F8F8F8F8F8
:0080 F0F0F0F0F0F0F0F0F0F0F0F0F0F0F0F0
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:00C0 C0C0C0C0C0C0C0C0C0C0C0C0C0C0C0C0
:00D0 C0C0C0C0C0C0C0C0C0C0C0C0C0C0C0C0
:00E0 80808080808080808080808080808080
:00F0 00000000000000000000000000000000
```

EDN

To Vote For This Design, Circle No.746

Serial interface moonlights as timer

Ken Bartlett
Konica Technology Inc, Sunnyvale, CA

Single-chip microcontrollers come equipped with one or more hardware timers and one or two serial ports. In some applications, designers never have enough hardware timers, although the serial ports often go unused. In these cases, you may be able to use the serial port as a timer. To implement the serial-port timer, configure the port as a normal write port and choose the baud rate and character length according to the time interval you desire. The timer's interval will equal the character length, including start and stop bits, divided by the baud rate. You start the timer interval by writing a byte to the serial port; the interval ends when the port completely shifts the character and sets its transmit-complete flag. You can poll this flag or use it to cause an interrupt.

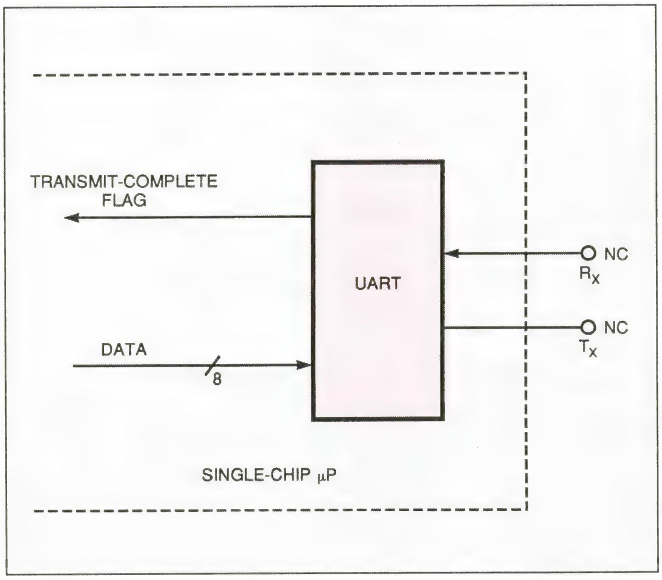


Fig 1—If you're not using one of the serial ports *available on your single-chip µP, consider using it as a timer. Simply write to the port, and the transmit-complete flag will go active at the time set by the character length and your system's baud rate.*

The range of timer intervals varies from microcontroller to microcontroller and depends on the system clock frequency and the range of adjustment of the baud rate generator. When an 8338-MHz crystal drives the serial-communications interface on Motorola's 68HC11 internal baud-rate generator, you can achieve 64 different delay times. These times range from 76.3 µsec (prescaler = 1, counter = 1, character length = 10 bits) to 139.65 msec (prescaler = 4, counter = 128, character length = 11 bits). For those microcontrollers that don't have an internal baud-rate generator such as the 8051, this technique is limited. You'll probably have to use one of the hardware timers simply to implement the necessary baud-rate generator. In this case, the primary utility of this technique may be to achieve longer delays than are possible with the timer alone. EDN

To Vote For This Design, Circle No. 750

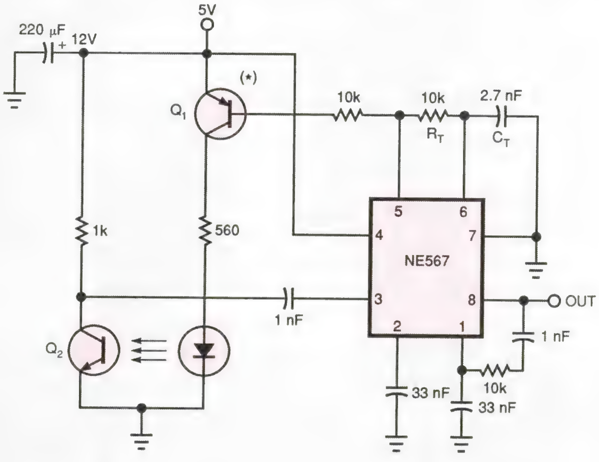
Single IC senses optical interruptions

Joao Paulo Sousa
Instituto de Engenharia de Sistemas e Computadores, Porto, Portugal

Using only one 8-pin IC and a few discrete components, you can build the infrared optical interrupter circuit shown in **Fig 1**. The NE567 tone decoder has all the necessary circuit elements: a local oscillator, a PLL decoder, and a 100-mA output-drive capability. The local oscillator, which is tuned to 40 kHz by R_T and C_T, drives Q_1, a universal low-power silicon pnp transistor such as a 2N3906, BC559, or ZTX500. Q_1 in turn drives the IR-emitting diode. The receiving part of the circuit surrounds the IC's internal PLL input at pin 3. When the photodetector, Q_2, detects the oscillating IR light beam, the 40-kHz signal appears at pin 3 of the IC. Under this condition, the circuit locks and the IC's output is high. When something opaque comes between the LED and Q_2, the 40-kHz signal doesn't reach the PLL input, and the IC's output goes low.

The feedback network between pins 1 and 8 prevents the output from chattering (**Fig 2**). If you connect this circuit to a high-inertia load such as a mechanical relay, the output doesn't tend to oscillate and you can eliminate these feedback components. The circuit works with virtually any LED-photodetector pair, but matched pairs allow for longer distances between the emitter and receiver. **Fig 1** lists some of the best choices. EDN

To Vote For This Design, Circle No. 749



Source	Detector	Manufacturer	Notes
TIL 32	TIL 78	Texas Instruments	IR LED and phototransistor
TIL 38	TIL 414	Texas Instruments	IR LED and phototransistor
CQY58A	BPW22A	Philips	IR LED and phototransistor
CQY89A	BPW 50	Philips	IR LED and pin photodiode
TIL 139		Texas Instruments	Transmissive source and detector assembly
TIL 149		Texas Instruments	Reflective source and detector assembly

***Fig 1—The output of this optical interrupter circuit** is either low or high depending on whether IR light pulses reach Q_2.*

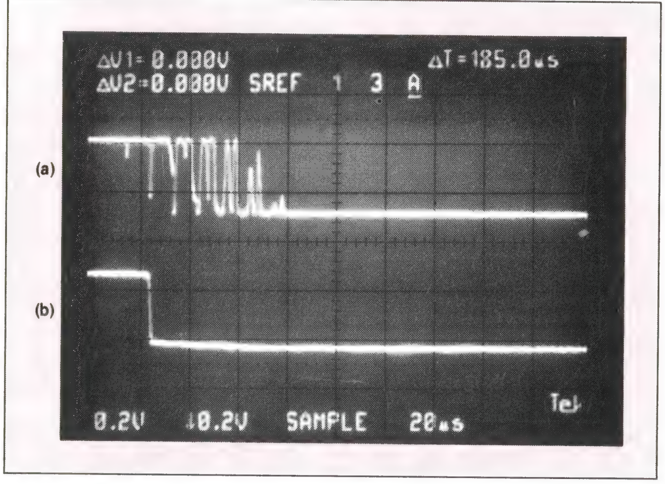
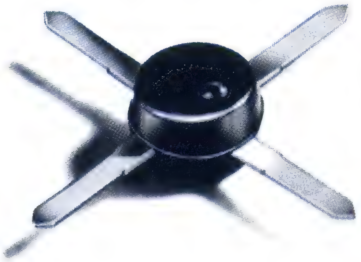


***Fig 2—The output chattering** in trace A is eliminated in trace B by adding the feedback components between pins 1 and 8.*

from 99¢



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*MAR-8, Input/Output Impedance is not 50ohms, see data sheet.
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SPECIFICATIONS

MODEL	FREQ. MHz	GAIN, dB 100 MHz	1000 MHz	2000 MHz	Min. (note)	• MAX. PWR. dBm	NF dB	PRICE $ Ea.	Qty.
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MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8 ☐	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

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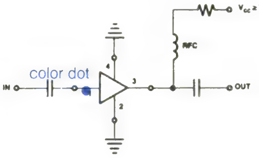

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CIRCLE NO. 77

Flip-flop debounces switch

Alexander Hillis
Teledyne Gurley, Troy, NY

The 2-bit counter shown in **Fig 1** is clocked by a debounced, normally open, pushbutton switch. The circuit is ideally suited for the manual-scanning control of a 4-channel data selector or analog multiplexer from the front panel of portable instruments. Although this circuit uses a 74HC74, any CMOS variant of this flip-flop will work. IC_{1A} acts as a true/complement buffer. R_1 and R_2 ensure that IC_{1A} comes out of reset prior to the occurrence of the clock's edge. R_3 applies IC_{1A}'s logic state to pins 1 and 3. When the switch closes, the next logic state stored on the capacitor transfers to the flip-flop's reset and clock inputs. Releasing the switch lets the capacitor charge to the next state via R_4. IC_{1A}'s output is the LSB; IC_{1B}'s output is the MSB. Note that the counter's state advances when the switch is first pressed, rather than when it's released; the latter is the case with many other switch debouncing schemes. You can replace R_1 with a 22-pF capacitor to reduce the circuit's sensitivity to parasitic effects. The addition of this capacitor also lets you lower the magnitude of R_2 and R_3 by a factor of ten.

To Vote For This Design, Circle No 748

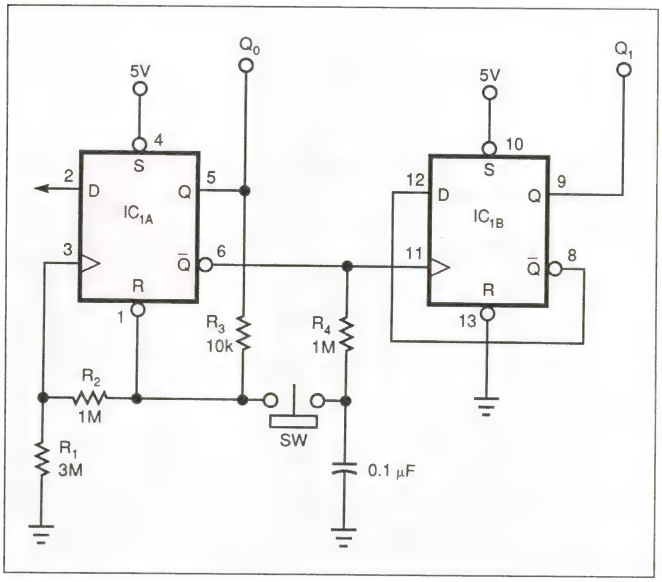

***Fig 1—Pressing the pushbutton switch** causes C_1's stored charge to either reset or clock this 2-bit counter/debouncer.*

FEEDBACK AND AMPLIFICATION

Fake ROM protects against pirates

Mr Srinivas's design idea, "Circuit renders ROM contents secure," on page 258 of the June 9, 1988, issue of EDN is a good idea, but it doesn't appear to be 100% immune to data pirates. His idea states that when one of the special unused addresses is accessed, the ASIC's select logic is "permanently" disabled. It isn't clear whether he means "permanent until power is cycled" or "forever permanent." In either case, a pirate can overcome this obstacle. If the logic is disabled until the power is cycled, it wouldn't take long for a pirate to deduce that reading certain addresses was disabling the EPROM. The pirate could then map out and avoid key addresses. In the case of "permanent forever," a pirate would only need access to several chips to "map and destroy" the entire contents. And in the "permanent forever" scenario, every time software hiccups or address-line glitches due to ESD or noise occur, the system will go down until you're able to procure a new part.

Instead of permanently disabling the ASIC, why not have the ASIC provide a "fake" ROM once an invalid address is hit. In other words, design two ROMs inside the ASIC, one "real" and one "fake." Once an invalid address is hit, the extra circuitry could automatically switch over to the invalid ROM until some other event occurs, such as a power cycle. The person copying the ROM would hardly suspect and probably almost never be able to tell when invalid code was being dumped by the ASIC instead of valid code.

Brady Barnes, Design Engineer
Inter-tel Inc
6505 W Chandler Blvd
Chandler, AZ 85226

Correction

I was delighted to see my design idea, "Single shots reside in PLDs," on page 244 of the June 22, 1989, issue of EDN. However, it contains two errors, which I would like to correct. First, in the last sentence of the third paragraph, "high-to-low" should read "low-to-high." Also, the timing equation at the bottom of the first column only applies for small values of C. The correct equation for the stated conditions is

$$T = -RC \times \ln(1-(V_D/(V_{CC}-V_{TH}))).$$

Jim Honea, Design Engineer
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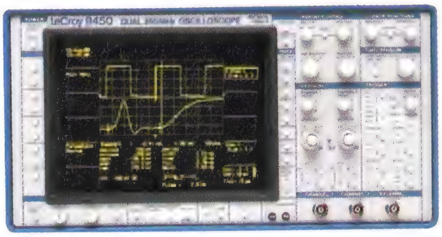

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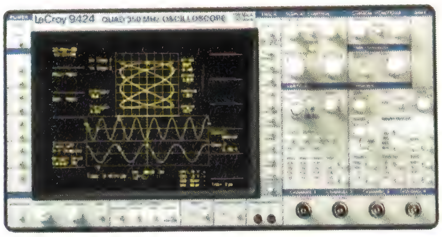

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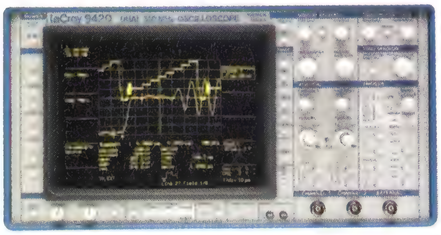

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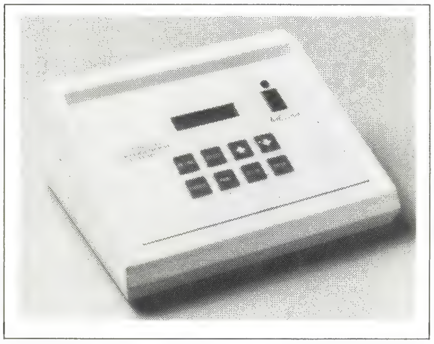
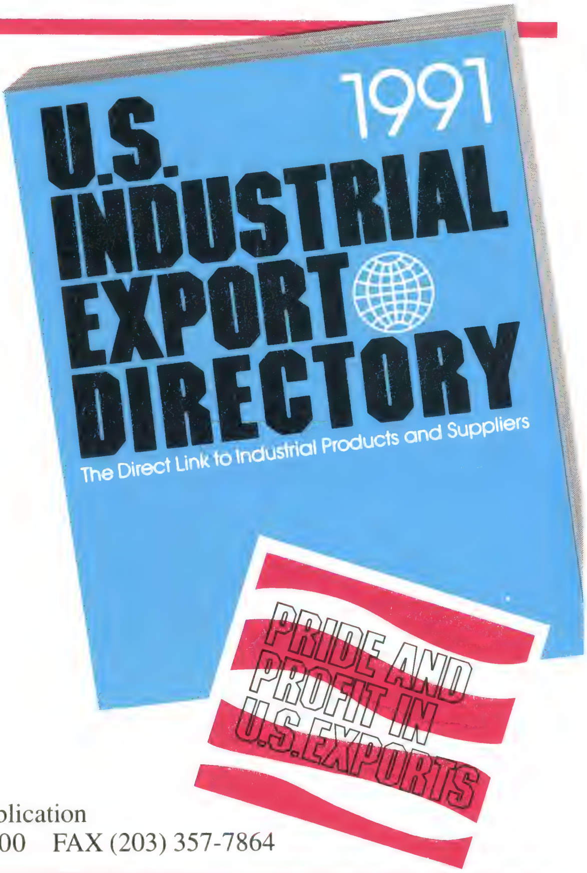


The JetCenter multiplexer gives as many as six users shared access to the features of any printer with HP LaserJet or LaserJet+ emulation. It has four centronics parallel ports and two RS-232C ports, which can be configured for any combination of inputs and outputs. Twinax attachments for IBM AS/400 and S/3X computers will be available in early 1990. A standard unit contains a 256k-byte data buffer that is expandable to 768k bytes. Preset for-



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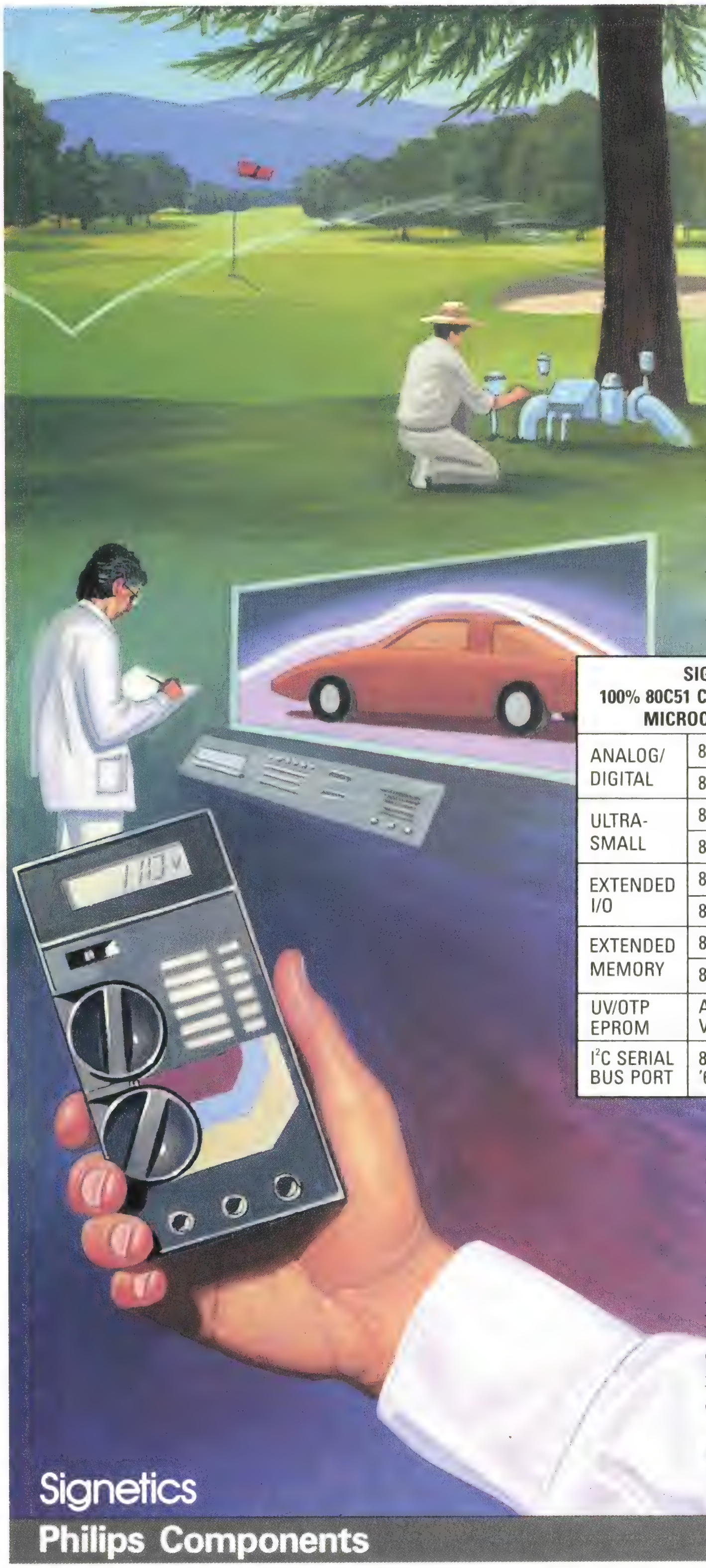

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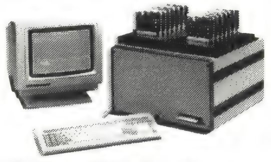

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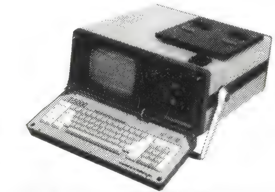

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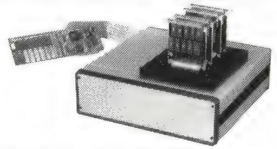

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28	29	30	31			

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Disneyland Hotel, Anaheim, CA (MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 617/232-3976)

16-17 Career Expo
Embassy Suites, Columbus, OH (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721 3030)

16-18 6th Annual Winter Computer Graphics Show
Jacob K. Javits Convention Center, New York, New York (David Small, Exhibition Marketing & Management, 8300 Greensboro Dr., Ste. 1110, McClean, VA 22102 703/758-8700)

16-18 AFCEA Military/Government Computing Conference & Exposition
Washington, D.C. (Judy Spargo-McDonald, J. Spargo & Associates, 4400 Fair Lakes Court, Fairfax, VA 22033 703/631 6200)
OH (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721 3030)

17 Status 1990 Integrated Circuits Seminar
Hilton, Sunnyvale, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

17-19 Western Simulation Multiconference
San Diego, CA (The Society for Computer Simulation, PO Box 17900, San Diego,CA 92117 619/277-3888)

18 Invitational Computer Conference
Munich Sheraton, Munich, West Germany (Invitational Computer Conferences, 3151 Airway Ave. Bldg. C-2 Costa Mesa, CA 92626 714/957-0171)

23 Invitational Computer Conference
Hilton International Wien, Vienna, Austria (Invitational Computer Conferences, 3151 Airway Ave., Bldg. C-2, Costa Mesa, CA 92626 714/957-0171)

23-25 1990 International Conference on Wafer Scale Integration
Fairmont Hotel, San Francisco, CA (Joe Brewer, Westinghouse Electric Corp., PO Box 746, M/S 5240, Baltimore, MD 21203 301 765-1247)

24 Status 1990 Integrated Circuits Seminar
Embassy Suites Hotel, Scottsdale, AZ (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale AZ 85260-2476 602-998-9780)

24-27 Internepcon Japan
Tokyo, Japan (Jean Skolnik, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-0833 203/964-0000)

30 Basic Integrated Circuit Technology Seminar
Radisson Plaza, Austin, TX (Patricia Fruscello, ICE 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

30 Invitational Computer Conference
Paris Sofitel, Paris, France (Invitational Computer Conferences, 3151 Airway Ave., Bldg. C-2, Costa Mesa, CA 92626 714/ 957-0171)

31 Status 1990 Integrated Circuits Seminar
Radisson Plaza, Austin, TX (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

31 SEMICON/Southwest
Infomart, Dallas, TX (Shows Department, Semiconductor Equipment and Materials International Headquarters, 805 East Middlefield Rd., Mountain View, CA 94043 415/964-5111)

Photo courtesy of IBM

1971— IBM introduced the first flexible magnetic disk. "Floppies" greatly increased the convenience of data handling.

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FEBRUARY 1990

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11	**12** Lincoln's Birthday	13	14	15	16	17
18	**19** Washington's Birthday	20	21	22	23	24
25	26	27	**28** Ash Wednesday			

5-8 Communication Networks '90
Washington Convention Center, Washington, D.C. (Dorothy Ferriter, IDG Conference Management Group, PO Box 9171, 20 Speen St., Framingham, MA 01701-9171 508/879-6700 or 800/225-4698)

6-8 1990 6th IEEE/CHMT Semiconductor Thermal & Temperature Measurement Symposium
Sunburst Resort Hotel, Scottsdale, AZ (Bonnie Crystall, C/S Communications, PO Box 23899, Tempe, AZ 85285 602/967-7444)

8 Invitational Computer Conference
London Hilton, London, England (Invitational Computer Conferences, 3151 Airway Ave., Bldg. C-2, Costa Mesa, CA 92626 714/957-0171)

12-14 1990 IEEE 3rd Annual Workshop on Micro Electromechanical Systems (MEMS)
Silverado Country Club and Resort, Napa Valley, CA (Katherine Blosch, Preferred Meeting Management, 640 E. Wilmington Ave., Salt Lake City, UT 84106 801/466-3500)

12-15 Systems/USA
New San Jose Convention Center, San Jose, CA (Paul LaGris, American Electronics Association, 5201 Great America Parkway, Santa Clara, CA 95054 714/966-1526)

13-15 SEE/West '90
San Jose Convention Center, San Jose, CA (Bud Mansler, Cartlidge & Assoc., Inc., 3097 Moore Park, Ste. 202, San Jose, CA 95128 408/554-6644)

13-15 1990 IEEE Instrumentation and Measurement Technology Conference (IMTC '90)
Red Lion Inn, San Jose, CA (Robert Myers, Conference Coordinator, 1700 Westwood Blvd., Ste. 101, Los Angeles, CA 90024 213/475-4571)

14-16 Buscon West
Long Beach Convention Center, Long Beach, CA (Reed Bocchino, Conference Management Corp., 200 Connectticut Ave., Norwalk, CT 06856-4990 203/852-0500)

14-16 1990 IEEE International Solid-State Circuits Conference (ISSCC '90)
San Francisco Hilton, San Francisco, CA (D. Suiters, Courtesy Assoc., Ste. 300, 655 15th St. NW, Washington, D.C. 20005 202/347-5900)

15 Status 1990 Integrated Circuits Seminar
Omni Parker House, Boston, MA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

21-23 11th AFCEA Western Conference & Exposition
Long Beach Convention Center, Long Beach, CA (Judy Spargo-McDonald, J. Spargo & Associates, 4400 Fair Lakes Court, Fairfax, VA 22033 703/631-6200)

22 Basic Integrated Circuit Technology Seminar
Hotel International, Zurich, Switzerland (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

26-March 1 Spring National Design Engineering Show & Conference
McCormick Place Complex, North Hall, Chicago, IL (Nancy Walsh, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-0833 203/964-0000)

26-March 2 International Electrical & Electronics Exhibition (ELECTREX)
National Exhibition Centre, Birmingham, England (Electrex Ltd., Wix Hill House, West Horsley, Surrey, England KT24 6DZ (04-83-222-888)

27-March 1 Nepcon West
Anaheim Convention Center, Anaheim, CA (Jill Vanderlin, Cahners Exposition Group, 1350 E. Touhy Ave., PO Box 5060, Des Plaines, IL 60017-5060 312/299-9311)

27-March 1 Electronic Imaging Conference West
The Pasadena Center, Pasadena, CA (MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215 800/223-7126)

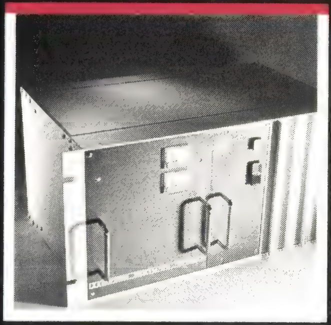

Photo courtesy of Dolby Laboratories

1965— Ray M. Dolby developed a noise reduction method known as "System A". The system eliminated background sound in recordings and improved fidelity. Continuing research led to the introduction of the now famous "Dolby Sound" used in motion picture audio delivery.

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then dare."

Helmuth von Moltke

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CIRCLE NO. 315

MARCH 1990

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11	12	13	14	15	16	**17** St. Patrick's Day
18	19	20	21	22	23	24
25	26	27	28	29	30	31

5-7 1990 Optical Data Storage Conference
Hyatt Regency Vancouver, BC, Canada (Wendy Rochelle, IEEE/LEOS, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331 201/562-3895)

5-9 Integrated Systems Digital Networks '90 (ISDN)
Phoenix Civic Plaza, Phoenix, AZ (Rosemarie Berube, Information Gatekeepers, Inc., 214 Harvard Ave., Boston, MA 02134 617/232-3111)

6-8 SEMICON/Europa
Zuspa Convention Center, Zurich, Switzerland (Shows Department, Semiconductor Equipment and Materials International Headquarters, 805 East Middlefield Rd., Mountain View, CA 94043 415/964-5111)

12-16 1990 IEEE Applied Power Electronics Conference and Exposition (APEC '90)
The Biltmore Hotel, Los Angeles, CA (Ann Beightol, Courtesy Associates, 655 15th St. NW, Ste. 300, Washington D.C. 20005 202/347-5900)

12-16 1990 IEEE International Conference on Computer Languages
Monteleone Hotel, New Orleans, LA (IEEE Computer Society, Conference Services, 1730 Massachusetts Ave. NW, Washington, D.C. 20036-1903 202/371-1013)

13-15 Sensors Expo West '90
Longbeach Convention Center, Longbeach, CA (Susan Reuter, Expocon Management Associates, 3695 Post Rd., Southport, CT 06490 203/374-1414)

19-22 Federal Government Information Systems Exposition
Washington Convention Center, Washington D.C. (Katherine Mudafort, National Trade Productions, 313 South Patrick St., Alexandria, VA 22314 703/683-8500)

19-22 NCGA '90
Anaheim Convention Center, Anaheim, CA (Irene Cahill, National Computer Graphics Association, 2722 Merrilee Dr. Ste. 200, Fairfax, VA 22031 703/698-9600)

20-22 Southcon '90
Orange County Convention Center, Orlando, FL (Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 213/772-2965)

20-22 Nepcon Europe
Birmingham, England (Jean Skolnik, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-0833 203/964-0000)

20-22 Semiconductor International
National Exhibition Centre, Birmingham, England (Reed Exhibition Companies, Ltd., Oriel House, 26, The Quadrant, Richmond TW9 1DL., England 0323-410335)

26 Invitational Computer Conference
Tysons Marriott, Tysons Corner, VA (Invitational Computer Conferences, 3151 Airway Ave., Bldg. C-2, Costa Mesa, CA 92626 714/957-0171)

26-29 1990 International Reliability Physics Symposium
New Orleans Marriott, New Orleans, LA (Alfred L. Tamburrino, RADC/RBRP, Griffiss AFB N.Y. 13441-5700 315/330-2813)

26-30 1990 12th International Conference on Software Engineering
Nice Acropolis, Nice, France (IEEE Computer Society, Conference Services, 1730 Massachusetts Ave. NW, Washington DC 20036-1903 202/371-1013)

27-29 RF Technology Expo
Anaheim Convention Center, Anaheim, CA (Linda Fortunato, Cardiff Publishing Co., 6300 S. Syracuse Way, Ste. 650, Englewood, CO 80111 303/220-0600)

29-31 Internepcon/Semiconductor Korea
Seoul, Korea (Jean Skolnik, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-0833 203/964-0000)

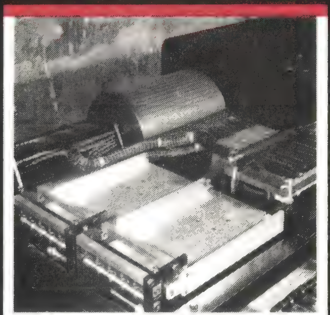

Photo courtesy of Charles Babbage Institute, University of Minnesota

1942— The Atanasoff-Berry Computer (or ABC) was assembled. The ABC was the first operational computer that used vacuum tubes to perform mathematical operations. In 1973 the U.S. Patent Office recognized John V. Atanasoff's ABC patent as valid, thus establishing it as the first modern electronically based computer.

> "Mere imagination would indeed be mere trifling; only no imagination is *mere*."
>
> Charles S. Pierce

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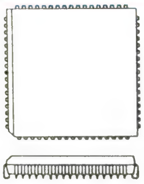
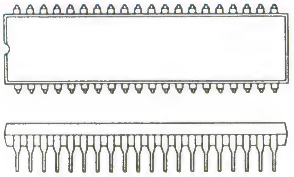


MD1210-1 (68-pin PLCC)



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CIRCLE NO. 316

APRIL 1990

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News Edition

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8 Palm Sunday	9	**10** Passover	11	12	**13** Good Friday	14
15 Easter Sunday	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

1-4 SOUTHEASTCON '90
Doubletree Hotel, New Orleans, LA (Robert Bush, South Central Bell, Room 1010, 365 Canal St., New Orleans, LA 70140 504/528-2598)

3-6 IEEE 1990 International Conference on Acoustics, Speech & Signal Processing (ICASSP)
Albuquerque Convention Center, Albuquerque, NM (Prof. Don Hush, EE/CE Dept., University of New Mexico, Albuquerque, NM 87131 201/582-4985)

3-5 1990 4th Working Conference on Current Measurement
Colony South Hotel, Clinton, MD (Gerald Appell, NOAA, Code N/OMA 41, 6001 Executive Blvd., Rockville, MD 20852 301/443-8026)

12 Invitational Computer Conference
Marriott Marquis, New York, NY (Invitational Computer Conferences, 3151 Airway Ave., Bldg. C-2, Costa Mesa, CA 92626 714/957-0171)

15-19 SUPERCOMM/ICC '90 (1990 International Conference on Communications)
Hyatt Hotel/Georgia World Congress Center, Atlanta, GA (Robert Snelling, Southern Bell Center, Room 4505, Atlanta, GA 404/529-8993)

16-20 1990 Technical Symposia on Aerospace Sensing
Peabody Hotel & Orange County Convention/Civic Center, Orlando, FL (Sue Davis, The International Society for Optical Engineering, PO Box 10, Bellingham, WA 98227 206/676-3290)

17-20 INTERMAG '90
Metropole Hotel, Brighton, England (Courtesy Assocs., Ste. 300, 655 15th St. NW, Washington, DC 20005 202/639-5088)

18-21 Internepcon China '90
Beijing, People's Republic of China (Jean Skolnick, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-0833 203/964-0000)

19 Invitational Computer Conference
Troy Hilton, Troy, MI (Invitational Computer Conferences, 3151 Airway Ave., Bldg. C-2, Costa Mesa, CA 92626 714/957-0171)

23-25 American Power Conference
Illinois Institute of Technology, Chicago, IL (Robert Porter, Illinois Institute of Technology, Chicago, IL 60616 312/567-3202)

23-27 Eastern Simulation Multiconference
Nashville, TN (The Society for Computer Simulation, PO Box 17900, San Diego,CA 92111 619/277-3888)

24-26 Electronic Distribution Show & Conference
Las Vegas Hilton, Las Vegas, NV (Jane Thelen, Electronic Industry Show Corp., 222 S. Riverside Plaza, Ste. 2710, Chicago, IL 60606 312/648-1140)

24-26 British Electronics Week (BEW)
Olympia, Hammersmith Road, London W14 8UX, England (Evan Steadman Group, The Hub, Emerson Close, Saffron Walden, Essex England CB10 1HL. 0799-26699)

24-26 Communications
National Exhibition Centre, Birmingham, England (Reed Exhibition Companies, Ltd., Oriel House, 26, The Quadrant, Richmond TW9 1DL., England 0323-410335)

24-27 The Which Computer? Show
National Exhibition Centre, Birmingham, England (Reed Exhibition Companies, Ltd., Oriel House, 26, The Quadrant, Richmond TW9 1DL., England 0323-410335)

29-May 3 1990 IEEE International Symposium on Circuits and Systems (ISCAS '90)
Sheraton New Orleans Hotel, New Orleans, LA (Artice Davis, EE Dept., San Jose State University, One Washington Square, San Jose, CA 95192-0084 408/929-3925)

30-May 1 1990 IEEE Technical Conference on Rubber and Plastics Industries
Quaker Square Hilton Inn, Akron, OH (David Babich, General Tire & Rubber Company, Akron, OH 44329 216/798-2832)

Photo courtesy of Philips

1963— Philips introduced the audio tape cassette. The evolution of the magnetic recording of sound, from the early introduction of a winding cylinder to record sound to the later use of steel tape, led to the development of the commercially practical Compact Cassette that utilized plastic tape.

> "Never tell people how to do things. Tell them what to do and they will surprise you with their ingenuity."
>
> George Patton

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MAY 1990

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20	21	22	23	24	25	26
27	**28** Memorial Day	29	30	31		

6-9 1990 IEEE Vehicular Technology Conference
Holiday Inn-Crown Plaza, Orlando, FL (George McClure, 1730 Shiloh Lane, Winter Park, FL 32789 407/356-3782)

7-9 1990 International Conference on Computer Systems and Software Engineering (COMPEURO '90)
Tel-Aviv, Israel (COMPEURO '90, ORTRA Ltd., PO Box 50432, Tel-Aviv 61500, Israel 972/3-664825)

8 Semiconductor Packaging Seminar
Hilton, Sunnyvale, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

8 Invitational Computer Conference
Boston Park Plaza Hotel & Towers, Boston, MA (Invitational Computer Conferences, 3151 Airway Ave., Bldg. C-2, Costa Mesa, CA 92626 714/957-0171)

8-10 6th Annual Spring Computer Graphics Show
Expo Center, Chicago, IL (Exhibition Marketing & Management, David Small 8300 Greensboro Dr., Ste. 1110, McClean, VA 22102 703/758-8700)

9-11 Electro '90
Bayside & World Trade Center, Boston, MA (Ms. Anne Weber, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 213/772-2965)

13-17 1990 IEEE International Conference on Applications of Industrial Electronics Systems
Laromme Hotel, Jerusalem, Israel (Dr. Moshe Harpaz, Kibbetz Ein-Carmel, D.N. Hof-Carmel 30 860, Israel 972/4-844410)

13-18 1990 IEEE International Conference on Robotics and Automation
Hyatt Regency, Cincinnati, OH (Harry Hayman, PO Box 3216, Silver Spring, MD 20901 301/434-1990)

14-16 Optical Information Systems (OIS) International
Novotel, 1 Shortlands, Hammersmith, London W6 8DR, England (Meckler, Ltd., Grosvenor Gardens House, Grosvenor Gardens, London SW1W 0BS. 01-931-9985)

15-17 Midwest Electronics Exposition
St. Paul Civic Center, St. Paul, MN (MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215 800/223-7126)

20-23 1990 IEEE Electronic Component and Technology Conference
Bally Grand Hotel, Las Vegas, NV (Jim Bruorton, Kemet Capacitors, PO Box 5928, Greenville, SC 29606 803/963-6621)

21-24 1990 IEEE 32nd Cement Industry Technical Conference
Innisbrook Resort, Tarpon Springs, FL (E.A. Buehler, Polysius Corp., 180 Interstate North, Atlanta, GA 30339 404/955-3660)

21-25 National Aerospace and Electronics Conference (NAECON '90)
Dayton Convention Center, Dayton, OH (Sue Brown, ASD/ENES, Wright-Patterson AFB, OH 45433-6503 513/255-6281)

22-24 SEMICON/West
San Mateo Fairgrounds, San Mateo, CA (Shows Department, Semiconductor Equipment and Materials International Headquarters, 805 East Middlefield Rd., Mountain View, CA 94043 415/964-5111)

22-24 TRANSTECH EUROPE
Scottish Exhibition & Conference Centre, Glasgow, Great Britain (Scottish & Industrial Trade Exhibitions Ltd., 8a, Charlotte Square, Edinburgh England EH2 4DR. 0982-553683)

23-25 1990 2nd Intersociety Conference on Thermal Phenomena in the Fabrication and Operation of Electronic Components
Balley Hotel, Las Vegas, NV (Paul Wesling, Tandem Computers, 19333 Vallco Pkwy., Cupertino, CA 95014 408/725-6472)

23-26 1990 IEEE/MTT-S International Microwave Symposium (MTT '90)
Hyatt Regency, Dallas, TX (John Wassel, Texas Instruments, Inc., M/S 245, PO Box 655074, Dallas, TX 75265 214/995-3216)

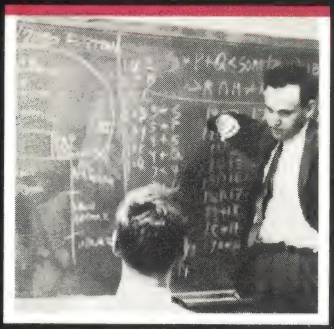
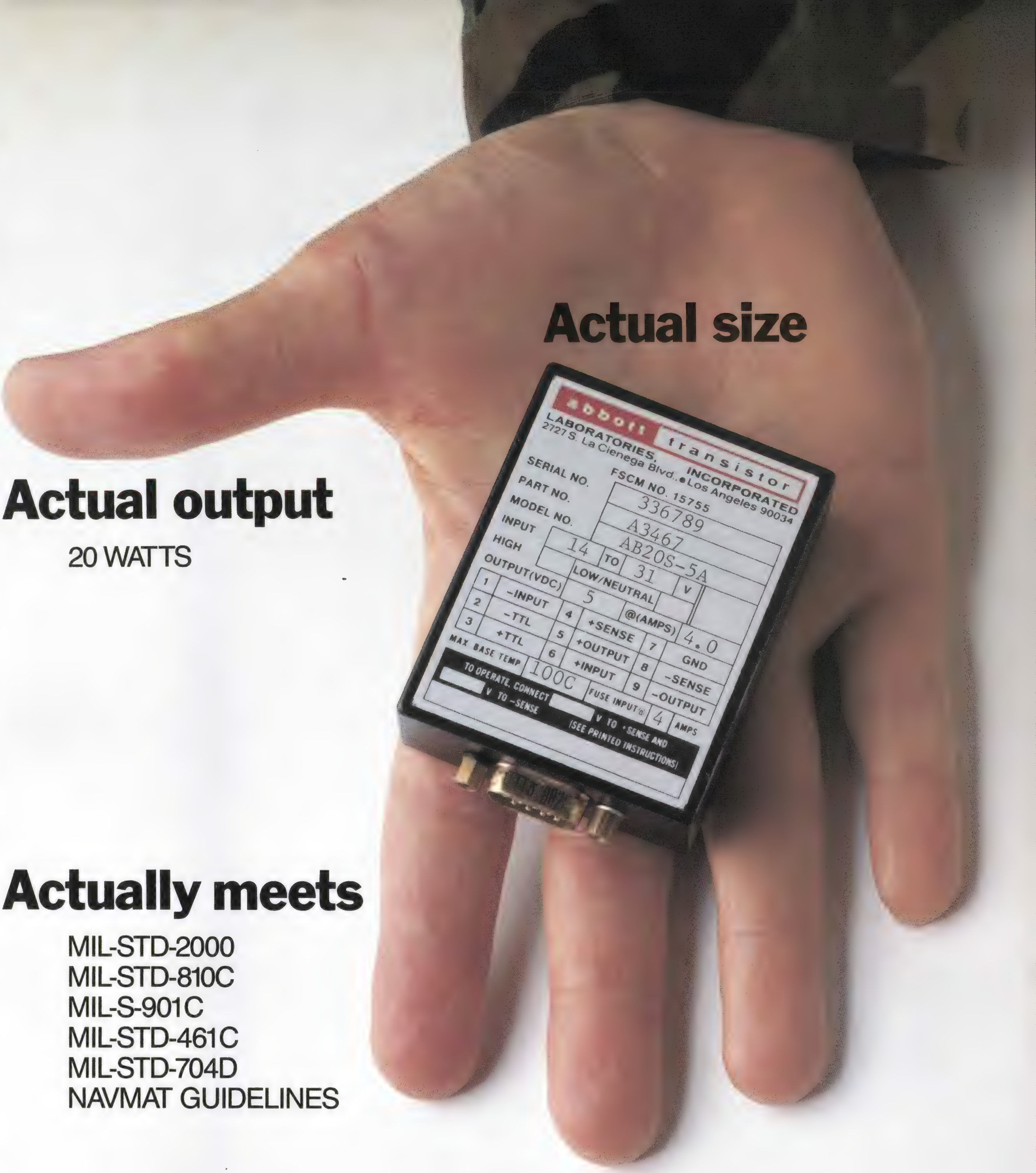


Photo courtesy of IBM

1956— FORTRAN (or FORmula TRANslation) was introduced as the first computer programming language. The effort, spearheaded by John Backus and his development team at IBM, replaced hard wiring as a means to programming a computer.

> "Every tool carries with it the spirit by which it has been created."
>
> Werner Heisenberg



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10	11	12	13	**14** Flag Day	15	16
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24	25	26	27	28		

2-5 International Summer Consumer Electronics Show
McCormick Place Complex, Chicago, IL (Dennis S. Corcoran, Consumer Electronics Show, 1722 Eye St. NW, Washington D.C. 20006 202/457-8700)

3-6 Comdex Spring
Georgia World Congress Center, Atlanta, GA (Interface Group, 300 First Ave., Needham, MA 02194 617/449-6600)

3-7 IEEE INFOCOM '90
San Francisco, CA (John Silvester, Dept. of EE Systems, SAL 340, University of Southern California, Los Angeles, CA 90089-0781 213/743-8189)

5-7 ATE & Instrumentation Conference East
World Trade Center, Boston, MA (MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215 800/223-7126)

5-7 44th AFCEA International Convention and Exhibition
Washington D.C. Convention Center, Washington D.C. (AFCEA, Judy Spargo-McDonald, J. Spargo & Associates, 4400 Fair Lakes Court, Fairfax, VA 22033 , 703/631-6200)

10-15 1990 IEEE Power Electronics Specialist Conference (PESC '90)
Hilton Palacio Del Rio, San Antonio, TX (Dr. Mehrdad Ehsani, Dept. of Electrical Engineering, Texas A&M University, College Station, TX 77843-7441 409/845-7441)

11-14 1990 IEEE Conference on Precision Electromagnetic Measurements (CPEM '90)
Westin Hotel, Ottawa, Canada (Huguette Lacoste, Conference Services, National Research Council, Ottawa, Ontario, Canada K1A 0R6 613/993-9431)

12-14 Nepcon East
Bayside Expo & World Trade Center, Boston, MA (Janet Schaffer, Cahners Exposition Group, 1350 E. Touhy Ave., PO Box 5060, Des Plaines, IL 60017-5060 312/299-9311)

12-14 9th Canadian CAD/CAM & Robotics Exhibition
Toronto International Centre, Toronto Ontario (David Valcourt, Reed-MacGregor Exhibitions, Inc., 800 Denison St., Unit 7, Markham, Ontario Canada L3R 5M9 416/479-3939)

15-21 PC User Show
Olympia, Hammersmith Road, London W14 8UX, England (EMAP International Exhibitions, 12, Bedford Row, London WC1R 4DU 01-404 4844)

19-21 8th Annual PC Expo in New York
Jacob K. Javits Convention Center, New York, New York (Mark Haviland, H.A. Bruno Inc., 385 Sylvan Ave., Englewood Cliffs, NJ 07632 201/569-8542)

19-21 Supercomputing World '90
San Diego Convention Center, San Diego, CA (Cathy Gibson, MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215 800/223-7126)

19-21 UNIX European User Show
Olympia, London, England (EMAP International Exhibitions, 12, Bedford Row, London WC1R 4DU 01-404 4844)

19-21 Networks Exhibition & International Conference
National Exhibition Centre, Birmingham, England (Blenheim-Online Ltd., Blenheim House, Ash Hill Drive, Pinner, Middx. HA5 2AE 01-868 4466)

19-21 ATE Instrumentation Conference East
World Trade Center, Boston, MA (MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 617/232-3976)

24-28 1990 ACM/IEEE Design Automation Conference
Orlando, FL (Design Automation Conference, PO Pistilli, MP Associates, 7366 Old Mill Trail, Boulder, CO 80301 303/530-4562)

26-28 1990 20th International Symposium on Fault Tolerant Computing
The Crest Hotel, Newcastle upon Tyne, England (IEEE Computer Society, Conference Services, 1730 Massachusetts Ave. NW, Washington D.C. 20036-1903 202/371-1013)

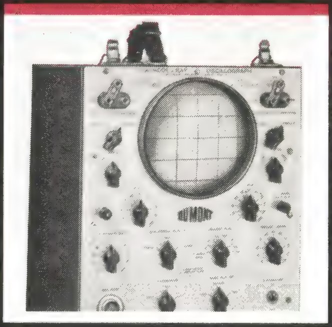

Photo courtesy of Antique Wireless Assn. Electronic Communication Musuem

1897— Karl Braun invented the oscilloscope. This invention led to the development of the iconoscope, a tube created for use in the television. The model shown above, the "Type 241 Cathode-Ray Oscillograph" was manufactured by Dumont in 1943.

> "I say to you in all sadness of conviction, that to think great thoughts you must be heroes as well as idealists."
>
> Oliver Wendell Holmes, Jr.

JULY 1990

EDN Magazine Edition News Edition

1	2	3	**4** Independence Day	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

11-13 Military Microwaves (MM)
Wembley Exhibition Centre, London, England (Microwave Exhibitions & Publishers Ltd., 90, Calverley Road, Tunbridge Wells, Kent TN1 2UN. 0892 544027)

16-17 Career Expo
Melbourne Hilton, Holiday Inn Airport, Melbourne, FL (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721-3030)

16-19 Summer Computer Simulation Conference
Calgary, Alberta, Canada (Linc Fish, The Society for Computer Simulation, PO Box 17900, San Diego,CA 92217 619/277-3888)

24-25 Training Seminar For Visual Inspection of ICs and Hybrids
Omni Parker House, Boston, MA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

30-31 Career Expo
Radisson Hotel, Columbus, OH (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721-3030)

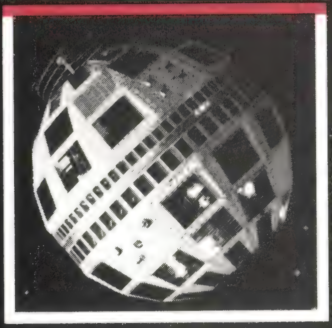

Photo courtesy of National Aeronautics and Space Administration

1962— Telstar was launched on July 10th. As the first satellite capable of active transmission, Telstar's launch inaugurated a new era in telecommunications. Telstar's initial task was the transmission of the first trans-Atlantic television pictures.

> **"In completing one discovery we never fail to get an imperfect knowledge of others of which we could have no idea before, so that we cannot solve one doubt without creating several new ones."**

Joseph Priestley

AUGUST 1990

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5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
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5-10 Professional Electronics Trade Show
Riviera Hotel, Las Vegas (Clyde Nabors, National Electronics Sales and Service Dealers Assn., 2708 W. Berry, Ft. Worth, TX 76109 817/921-9061)

6-10 Siggraph '90
Dallas Convention Center, Dallas, TX (Barbara Voss, Robert T. Kenworthy Inc., 866 United Nations Plaza, New York, NY 10017 212/886-0300)

7 Basic Integrated Circuit Technology Seminar
Hilton, Sunnyvale, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

8 Mid-Term 1990 Integrated Circuit Seminar
Hilton, Sunnyvale, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

13-14 Career Expo
Holiday Inn, St. Louis, MO (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721-3030)

14 Basic Integrated Circuit Technology Seminar
Embassy Suites Hotel, Scottsdale, AZ (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

15 Mid-Term 1990 Integrated Circuit Seminar
Embassy Suites Hotel, Scottsdale, AZ (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

18-22 Internepcon/Semiconductor Taiwan
Taipei, Taiwan (Jean Skolnik, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-08333 203/964-0000)

20-24 1990 36th IEEE Holm Conference on Electrical Contacts in conjunction with the 15th International Conference of Electric Contacts
Le Grande Hotel, Montreal, Quebec, Canada (Registrar, IEEE Headquarters, 345 East 47th St., New York, NY 10017 212/705-7405)

20-24 1990 IEEE International Symposium on Electromagnetic Compatibility - EMC '90
Washington Hilton Hotel, Washington D.C. (Thomas W. Doeppner, 8323 Orange Court, Alexandria, VA 22309 703/780-3983)

21 Basic Integrated Circuit Technology Seminar
Omni Parker House, Boston, MA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

22 Mid-Term 1990 Integrated Circuit Seminar
Omni Parker House, Boston, MA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

27-28 Career Expo
Sheraton, Cincinnati, OH (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721-3030)

28 Basic Integrated Circuit Technology Seminar
Sheraton, Newport Beach, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

28-30 Surface Mount '90
Bayside Expo Center, Boston, MA (MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02115 800/223-7126)

29 Mid-Term 1990 Integrated Circuit Seminar
Sheraton, Newport Beach, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

30-September 1 Internepcon Osaka
Osaka, Japan (Toshiki Koike, Cahners Exposition Japan, 46F Shinjuku-Nomura Bldg., 1-26-2 Nishishinjuku Shinjuku-ku, Tokyo 163 Japan 03-349-8501)

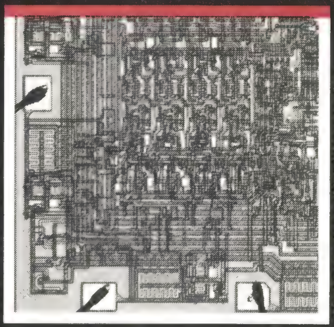

Photo courtesy of Intel Corporation

1971— EDN published an exclusive story on the first microprocessor, developed by Ted Hoff for Intel. Though measuring 1/8th inch by 1/6th inch, the Intel 4004 had the computing power of the early ENIAC, which filled 3000 cubic feet and had 18,000 vacuum tubes.

> **"The greatest invention of the nineteenth century was invention."**
>
> **Alfred North Whitehead**

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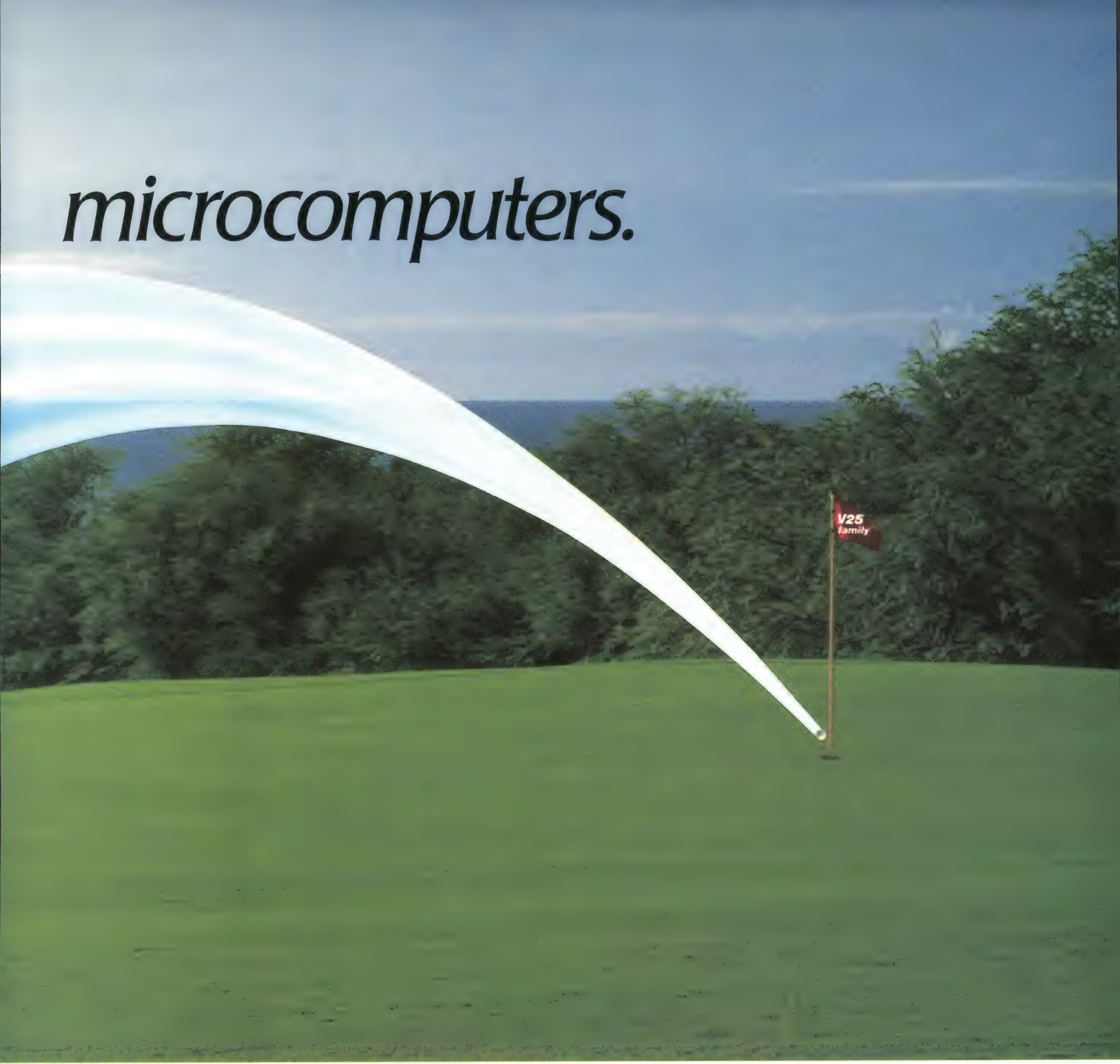
C&C Computers and Communications



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NEC

CIRCLE NO. 320

SEPTEMBER 1990

EDN Magazine Edition News Edition

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2	**3** Labor Day	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	**20** Rosh Hashanah	21	22
23/30	24	25	26	27	28	**29** Yom Kippur

2-9 Farnborough International Exhibition & Flying Display
Farnborough Airport, Hampshire, England (Society of British Aerospace Companies, Ltd., 29, King St., St. James's, London SW1Y 6RD 01-839 3231)

5-6 FED Micro
Washington Convention Center, Washington D.C. (Katherine Mudafort, National Trade Productions, 313 South Patrick St., Alexandria, VA 22314 703/683-8500)

9-13 International Test Conference
Sheraton Washington, Washington D.C. (Camie Jackson, LTX Corp., University Ave., Westwood, MA 02090 617/329-7550)

10-12 1990 Petroleum & Chemical Industry Technical Conference
Westin Galleria Hotel, Houston, TX (R.F. Barrett, ARAMCO Services Inc., PO Box 4534, Houston, TX 77210 713/432-5761)

11-13 Midcon
Dallas Convention Center, Dallas, TX (Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045 213/772-2965)

11-13 Fall Design Engineering Show & Conference
Jacob K. Javits Convention Center, New York, NY (Rick Dolson, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-0833 203/964-0000)

11-13 Sensors Expo International
O'Hare Exposition Center, Chicago, IL (Susan Reuter, Expocon Management Associates, 3695 Post Rd., Southport, CT 06490 203/374-1414)

17-21 AUTOTESTCON '90
San Antonio Convention Center, San Antonio, TX (Bob Hershey, Chairman, SA-ALC/SCC, Kelly AFB, San Antonio, TX 78241-5000 512/925-7313)

20-21 1990 40th Annual Broadcast Symposium
Washington Hotel, Washington D.C., (Otto R. Claus, WBAL-TV, 3800 Hooper Ave., Baltimore, MD 21211 301/338-6455)

24-28 Broadband FOC/LAN '90
Baltimore Convention Center, Baltimore, MD (Rosemarie Berube, Information Gatekeepers, Inc., 214 Harvard Ave., Boston, MA 02134 617/232-3111)

25-27 PC Expo in Chicago
McCormick Place North, Chicago, IL (Mark Haviland, H.A. Bruno Inc., 385 Sylvan Ave., Englewood Cliffs, NJ 07632 201/569-8542)

25-27 Assembly Technology Expo
Rosemont/O'Hare Exposition Center, Rosemont, IL (Barbara Silverman, Professional Exposition Management Co., 2400 E. Devon St., Ste. 205, Des Plaines, IL 60018 312/299-3131)

25-27 MILCOMP
Wembley Exhibition Hall, London, England (Microwave Exhibitions & Publishers Ltd., 90, Calverley Road, Tunbridge Wells, Kent TN1 2UN. 0892 544027)

25-27 British Laboratory Week (BLW)
Olympia, London, England (Evan Steadman Group, The Hub, Emerson Close, Saffron Walden, Essex CB10 1HL. 0799-26699)

25-27 AFCEA Philippine Conference & Exposition
Westin Phillipine Plaza Hotel, Manila, Philippines (AFCEA, Judy Spargo-McDonald, J. Spargo & Associates, 4400 Fair Lakes Court, Fairfax, VA 22033 , 703/631-6200)

Photo courtesy of Texas Instruments

1958— Jack Kilby demonstrated his integrated circuit at Texas Instruments on September 12th. The first commercially available "IC" cost $450, but would quickly drop in price. By 1988, Texas Instruments offered a 32-bit LISP processor that contained almost 700,000 transistors.

> "The most beautiful thing we can experience is the mysterious. It is the source of all true art and science."
>
> Albert Einstein

OCTOBER 1990

EDN Magazine Edition News Edition

	1	2	3	4	5	6
7	**8** Columbus Day	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	**31** Halloween			

1-3 1990 9th IEEE/CHMT International Electronic Manufacturing Technology Symposium
Ramada Renaissance Hotel, Washington D.C. (Bill Moody, 2529 Eaton Rd., Wilmington, DE 19810 302/478-4143)

7-12 1990 IEEE Industry Application Society Annual Meeting
Westin Hotel, Seattle, WA (Richard W. Becker, 612 Bellevue Way NE, Room 201, Bellevue, WA 98004 206/454-5440)

9-11 Northcon
Seattle Center Coliseum, Seattle, WA (Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 213/772-2965)

10-12 UNICOM '90
George R. Brown Convention Center, Houston, TX (Susan Ryba, North American Telecommunications Association, 2000 M St., Washington D.C. 20036 202/296-9800)

15-18 International Conference on Integrated Broadband Services and Networks
London, England (Conference Services, IEE, Savoy Place, London WC2R 0BL, United Kingdom 01/240-1871 Ext. 222)

15-17 International Society for Hybrid Microelectronics Symposium
McCormick Place, Chicago, IL (Richard Breck, International Society for Hybrid Microelectronics, PO Box 2698, Reston, VA 22090 703/471-0066)

15-18 Buscon East
Royal Trade Plaza, Marlboro, MA (Reed Bocchino, Conference Management Corp., 200 Connectticut Ave., Norwalk, CT 06856-4990 203/852-0500 ext. 232)

15-18 ISA '90/ Instrument Society of America
New Orleans Convention Center, New Orleans, LA (Brian Duckett, ISA, 67 Alexander Dr., Research Triangle Park, NC 27709 919/549-8411)

16 Basic Integrated Circuit Technology Seminar
Hilton, Sunnyvale, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

16-18 Sensors & Systems
Wembley Exhibition Centre, London, England (Trident Exhibitions Ltd., 21 Plymouth Road, Tavistock, Devon PL19 8AU England 0684-892751)

16-19 Design Engineering Show (DES)
NEC Birmingham, England (Reed Exhibition Companies, Ltd., Oriel House, 26, The Quadrant, Richmond TW9 1DL., England 0323-410335)

21-24 INTELEC '90 1990 IEEE International Telecommunications Energy Conference
Orlando, FL (Jim Fletcher, AT&T Technologies, 650 Liberty Ave., Union, NJ 07083 201/851-3077)

21-24 1990 IEEE GaAs Integrated Circuits Symposium
Hyatt Regency Hotel, Atlanta, GA (Kenneth J. Sleger, Naval Research Laboratory, Code 6852, Washington D.C. 20375 202/767-3894)

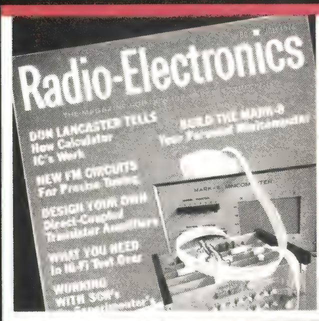
21-25 Joint Power Generation Power Conference - JPGC '90
Park Plaza, Boston, MA (Marisa Scalice, ASME, 345 E. 47th St., New York, NY 10017 212/705-7053)

23-24 Training Seminar For Visual Inspection of ICs and Hybrids
Hilton, Sunnyvale, CA (Patricia Fruscello, ICE, 15022 N. 75th St., Scottsdale, AZ 85260-2476 602-998-9780)

23-25 SEMICON/Japan
Nippon Convention Center, Makuhari, Japan (Shows Department, Semiconductor Equipment and Materials International Headquarters, 805 East Middlefield Rd., Mountain View, CA 94043 415/964-5111)

29-November 1 1990 Conference on Magnetism and Magnetic Materials
Town & Country Hotel, San Diego, CA (D. Suiters, Courtesy Assocs., Ste. 300, 655 15th St. NW, Washington, D.C. 20005 202/639-5088)

30-November 1 Electronic Imaging Conference East
Hynes Convention Center, Boston, MA (MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215 800/223-7126)



1974— *Radio-Electronics* featured an article describing how to build a personal computer designed by Jonathan Titus, now Editorial Director of EDN. The Mark-8 was based on Intel's 8008 microprocessor and is now being considered by the Smithsonian Institute for inclusion in a future exhibition.

> "Progress is not an accident...but a necessity."
>
> Herbert Spencer

NOVEMBER 1990

EDN Magazine Edition News Edition

				1	2	3
4	5	**6** Election Day	7	8	9	10
11 Veteran's Day	12	13	14	15	16	17
18	19	20	21	**22** Thanksgiving Day	23	24
25	26	27	28	29	30	

1-3 Unix Expo
Jacob K. Javits Convention Center, New York, NY (Don Berey, National Expositions Co., 15 W. 39th St., New York, NY 10018 212/391-9111)

1-4 Consumer Electronics, Camera and Computer Expo
Nassau Coliseum, Uniondale, NY (Rick Stuts, Expositions Inc., 100 W. Park Ave., Long Beach, NY 11561 516/889-6000)

5-6 Career Expo
Marriott, Huntsville, AL (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721-3030)

6-8 Computer Graphics
Alexandra Palace, London, England (Blenheim-Online Ltd., Blenheim House, Ash Hill drive, Pinner, Middx. HA5 2AE 01-868 4466)

6-8 DMC/PC Week
National Exhibition Centre, Birmingham, England (Evan Steadman Group, The Hub, Emerson Close, Saffron Walden, Essex CB10 1HL. 0799-26699)

6-10 Electronica
Munich Trade Fair Centre, Munich, West Germany (Gerald G. Kallman, Kallman Associates, 5 Maple Court, Ridgewood, NJ 07450-4431 201/652-7070)

7 "Simulation"
Broadcast from The Learning Channel (The Learning Channel, 1525 Wilson Blvd., Rosslyn, VA 22209 703/276-0881)

7-10 Internepcon/Semiconductor Asia/Pacific
Singapore (Jean Skolnik, Cahners Exposition Group, 999 Summer St., PO Box 3833, Stamford, CT 06905-08333 203/964-0000)

12-13 Career Expo
Marriott, Indianapolis, IN (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721-3030)

12-16 Comdex Fall
Las Vegas Convention Center, Las Vegas, NV (Interface Group, 300 First Ave., Needham, MA 02194 617/449-6600)

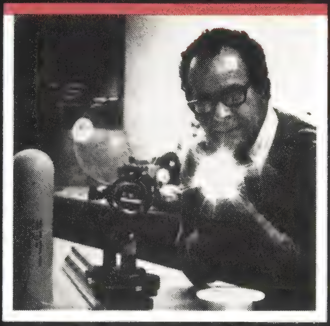
13-15 Autofact '90
Cobo Conference & Exhibit Center, Detroit, MI (Society of Manufacturing Engineers, One SME Dr., PO Box 930, Dearborn, MI 48121 313/271-1500)

13-15 Wescon '90
Anaheim Convention Center, Anaheim, CA (Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045 213/772-2965)

14-15 Nepcon Northwest
San Jose Convention/Cultural Facilities, San Jose, CA (Jerry Carter, Cahners Exposition Group, 1350 E. Touhy Ave., PO Box 5060, Des Plaines, IL 60017-5060 312/299-9311)

27-30 Scottish Engineering Exhibition- Design, Production, Automation
Scottish Exhibition & Conference Centre, Glasgow, United Kingdom (Scottish & Industrial Trade Exhibitions Ltd., 8a, Charlotte Square, Edinburgh EH2 4DR. 0982-553683)

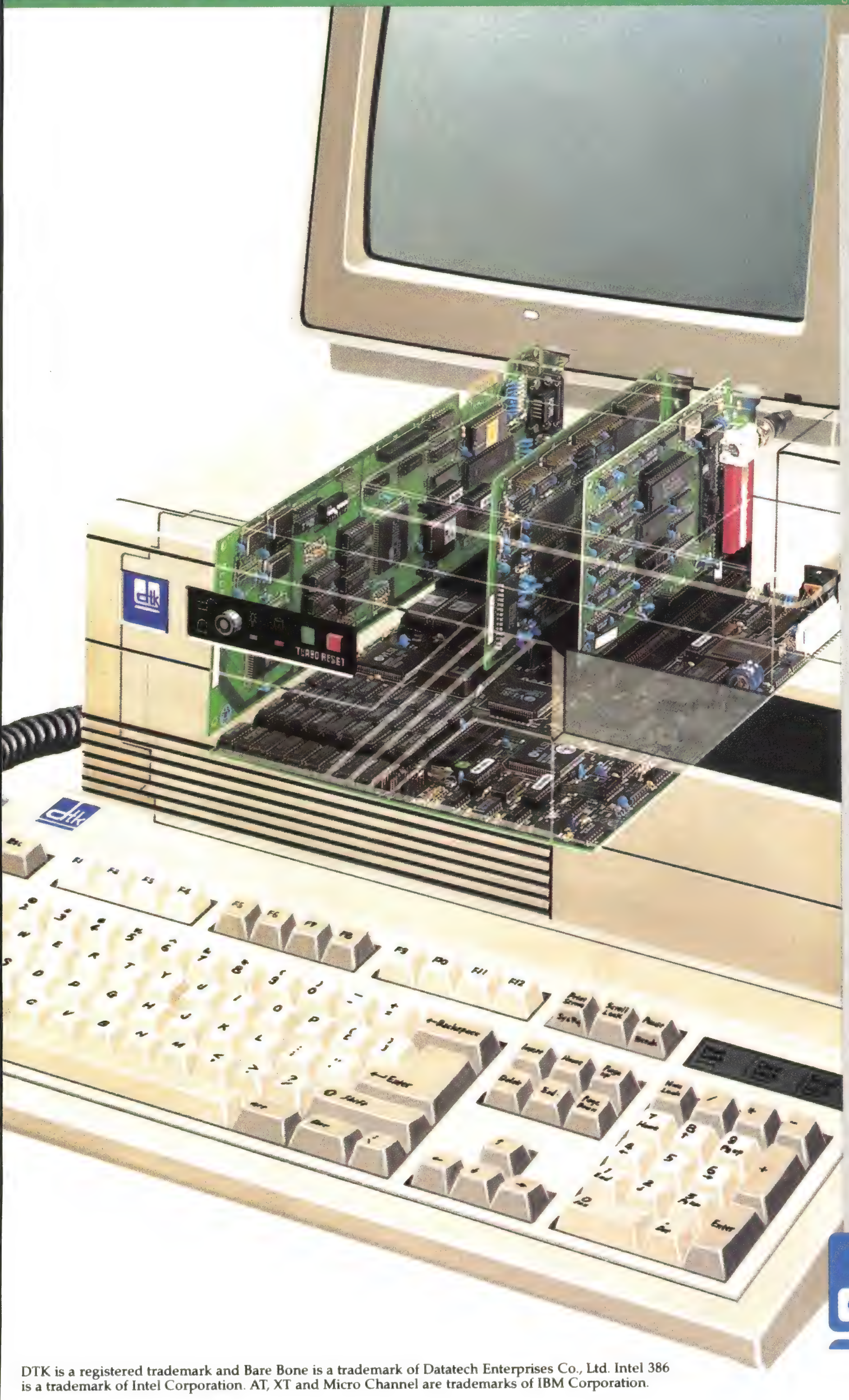
27-29 AFCEA Hawaii/USCINCPAC 5th Annual Pacific International Defense Electronics Conference & Exposition
Sheraton Waikiki Hotel, Honolulu, HI (AFCEA, Judy Spargo-McDonald, J. Spargo & Associates, 4400 Fair Lakes Court, Fairfax, VA 22033 , 703/631-6200)



1957— Gordon Gould began developing the laser (or "Light Amplification by Stimulated Emission of Radiation") on November 11th while a physics graduate student at Columbia. Lasers have since found applications in everything from check-out counter systems at supermarkets to use in the Strategic Defense Initiative (SDI).

> "Minds are like parachutes. They only function when they are open."
>
> Sir James Dewar

We've got the guts, you get the glory.



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DECEMBER 1990

EDN Magazine Edition News Edition

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2	3	4	5	6	7	8
9	10	11	**12** Chanukah	13	14	15
16	17	18	19	20	21	22
23/30	24/31	**25** Christmas Day	26	27	28	29

2-5 GLOBECOM '90 - 1990 IEEE Global Communications Conference
The Sheraton Harbor Island, San Diego, CA (Andrew Cohen, Qualcomm, 10555 Sorrento Valley Road, San Diego, CA 92121 619/587-1121)

3-4 Career Expo
Beachwood Marriott, Cleveland, OH (Bill Westerkamp, RSI Group, 2367 Auburn Ave., Cincinnati, OH 45219 513/721-3030)

5 "Fiber Optics Applications"
Broadcast from The Learning Channel (The Learning Channel, 1525 Wilson Blvd., Rosslyn, VA 22209 703/276-0881)

5-7 SEMICON/Korea
Korea Exhibition Center (KOEX), Seoul, Korea (Shows Department, Semiconductor Equipment and Materials International Headquarters, 805 East Middlefield Rd., Mountain View, CA 94043 415/964-5111)

5-7 1990 Ultrasonics Symposium
Sheraton Waikiki, Honolulu, HI (R.S. Kagiwada, Co-Chairman, TRW-ES6, Mail Station R6/1563, One Space Park, Redondo Beach, CA 90278)

Photo courtesy of AT&T

1947— William B. Shockley, Walter Brattain and John Bardeen unveiled the first transistor in Bell Labs on December 23rd, thereby making vacuum tubes obsolete. The team's twenty-year long research effort resulted in earning them the Nobel Prize for Physics in 1956.

> **"Human history is in essence a history of ideas."**
>
> **H. G. Wells**

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CIRCLE NO. 322

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Circle 323 for Product Information

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CIRCLE NO. 83

NEW PRODUCTS

INTEGRATED CIRCUITS

Audio DAC With THD + N Of −92 dB

- *Has 18-bit resolution*
- *Dynamic range is 108 dB*

The PCM61P is a monolithic 18-bit DAC designed for audio applications such as CD players and DAT (digital audio tape) equipment. Packaged in a 16-pin plastic DIP, the converter is pin compatible with its popular 16-bit predecessor, the PCM56P. However, with two added bits of resolution, the PCM61P has a THD + N spec of < −92 dB. Other specs include a dynamic range of 108 dB and idle channel S/N ratio of 112 dB. Differential nonlinearity is ±0.001% at bipolar zero, and 16-bit monotonicity is guaranteed over the 0-to-70°C temperature range. In single-channel audio applications, the PCM61P can achieve 8× oversampling rates in the V_{out} mode. Glitch-free outputs of either ±3V or ±1 mA are available. $14.05 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. FAX 602-889-1510.

Circle No. 372

BiCMOS PWM ICs

- *Low- and high-speed versions available*
- *Feature improved noise immunity*

According to the company, the TSC38HC42 BiCMOS family of PWM ICs delivers more than twice the output drive of the industry-standard 3842-45 bipolar family, which it replaces. The 38HC42 can drive a 2200-pF load in 55 nsec; the bipolar equivalent can drive a 1000-pF load in 150 nsec. The minimum controllable pulse width for the BiCMOS family is 350 nsec at 700 kHz for a 2000-mV/µsec ramp or 100 nsec for a 1V step. In addition, the noise immunity, or PSRR, of the error amplifier and current-sense amplifier has been improved from 70 to 100 dB min. The 16-pin-version TSC172 and TSC173 include a shutdown pin, a separate synch pin, and separate and internally isolated power and control pins. The devices are available in either 400-kHz or 1-MHz versions and in a variety of 8- and 16-pin packages. From $1.10 (50,000).

Teledyne Semiconductor, 1300 Terra Bella Ave, Mountain View, CA 94039. Phone (415) 968-9241. FAX 415-967-1590. **Circle No. 373**

BiCMOS Gate Array

- *Has 20,064 total gates*
- *Propagation delay is 0.8 nsec*

The SLA800B series of gate arrays combines the low-power and high-density characteristics of CMOS gates with the high-speed and high-drive capabilities of bipolar I/O buffers. The 20,064-gate chip features an internal power consumption of 15 µW/MHz for each 2-input NAND gate. At 24 mA of output drive, the input and output buffers typically require 48 and 400 µW/MHz, respectively. The I/O cells connect to 172 bonding pads. Directly compatible with the company's CMOS SLA8000 series, the SLA800B series features a typical propagation delay of 0.8 nsec. A variety of package options are available. Depending on complexity and packaging, $0.002 to $0.003/gate.

S-MOS Systems Inc, 2460 N First St, San Jose, CA 95131. Phone (408) 922-0200.

Circle No. 374

1M-Bit Static RAMs

- *Organized as 256k × 4 bits*
- *Feature 35-nsec access time*

Manufactured using a 0.8-µm CMOS process, the HM624256 and HM624257 are 1M-bit static RAMs (SRAMs) organized as 256k × 4 bits. The SRAMs feature access times of 35 and 45 nsec, and enable designers to upgrade existing 64k × 4-bit systems to obtain higher performance. The devices differ only in I/O connections: The HM624256 has common I/O and output enable connections, and the HM624257 has separate I/O connections that can simplify system design and improve throughput. The SRAMs are available in 28-pin (HM624256) and 32-pin (HM624257) plastic SOJ packages. 35-nsec version, $210; 45-nsec version, $190 (500).

Hitachi America Ltd, 2000 Sierra Point Pkwy, Brisbane, CA 94005. Phone (415) 244-7179. FAX 415-583-4207. **Circle No. 375**

Chopper-Stabilized Op Amp

- *Improves dc performance*
- *Operates from ±15V supply*

Designed as a substitute for usual bipolar op amps, the LTC1150 improves dc performance and operates from the standard ±15V supply with a maximum input offset voltage of only 5 µV. Included in the op amp are two S/H capacitors, which are usually required externally. Other specifications are a typical offset-voltage drift of 0.01 µV/°C, typical noise of 1.8 µVp-p from 0.1 Hz to 10 Hz, voltage gain of 140 dB min, CMRR of 120 dB min, and PSRR of 130 dB min. Unlike the input common-mode range of other devices, that of the LTC1150 includes ground, and the output swings to ground. Supply current is 800 µA; grounding pin 1 reduces this current to 200 µA. Packages include 8-pin DIP and SOIC and 8-pin TO-5 metal cans. In an 8-pin DIP, $3.85 (100).

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1900. FAX 408-434-0507. **Circle No. 376**

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CIRCLE NO. 84

NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

Flat-Panel Display

- *Offers a variety of character sets*
- *Handles data at 120k characters/sec*

Model 3102-XY-256 features eight lines of 32 characters formed by a 5×7 dot matrix with a separate underbar. The display is available in neon orange or in green. A US ASCII character set is standard, but general European, German, Scandinavian, Spanish, or Universal sets are available as options. Character attributes include underline and blinking. Housed in a 11.13×5.85×2.5-in. module, the unit has a 100° viewing angle. The display will accept parallel ASCII data at rates ranging to 120,000 characters/sec. All signal inputs are TTL-compatible CMOS with 10 kΩ pullups. Maximum power requirements are 150V dc at 58 mA and 5V dc at 238 mA. Neon-orange version, $698 (100). Delivery, six to eight weeks ARO.

IEE Inc, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. FAX 818-902-3723. TLX 4720556. **Circle No. 362**

Temperature Switches

- *Have a ±1°C accuracy*
- *Available in SIPs*

Series TS solid-state temperature switches come in remotely mountable stand-alone or in pc-board-mountable SIPs. The devices trip at specified temperatures from 1 to 65°C and have a ±1°C accuracy. They are available in NO or NC versions for 5 through 24V dc operation. The switches are compatible with most logic as well as relays and indicators. SIP units measure 0.48×1.2 in.; the stand-alone unit has a 0.5-in. diameter and is 3 in. long. $6 (5000).

Cambridge Aeroflo Inc, 800 Mount Laurel Circle, Shirley, MA 01464. Phone (508) 425-2346. FAX 508-425-2338. **Circle No. 363**

Prototyping Adapter

- *Designed for SIMM packages*
- *Features labeled test points*

The model ANC-9130 prototyping adapter simplifies the task of wire wrapping equipment prototypes that use standard 30-pin single in-line memory modules (SIMM) packages. Available with either 3-level wire-wrap or gold-machined pins, the adapter is designed to accommodate two of the leadless SIMM components. The unit provides la-

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beled test points for attaching oscilloscope or logic-analyzer probes. The 0.9-in. pin spacing allows the adapter to be used on a wide variety of prototype boards. The user's manual includes a template that you can use as a signal-to-pin designation guide. $61.

Antona Corp, 1643½ Westwood Blvd, West Los Angeles, CA 90024. Phone (213) 473-8995.
Circle No. 364

Resistor Network

- *Available in a variety of network configurations*
- *Features a ±2% tolerance*

Housed in a 0.300-in.-wide molded package with 16 or 20 gull-wing leads, the SOGC resistor network is available in a number of circuit configurations—15 or 19 resistors connected to one common lead (01 schematic), 8 or 10 isolated resistors (03 schematic), and with 14 or 18 pairs of resistors (05 schematic) for TTL dual-line termination and pulse-squaring applications. Available with resistance values ranging from 10Ω to 1 MΩ, the network has a standard tolerance of ±2% and a temperature coefficient of ±100 ppm/°C. Optional tolerances range from 1 to 20%. At 70°C, maximum power rating per resistor is 100 mW for 01 and 05 schematics and 190 mW for 03 units. Maximum package rating equals 1.6 and 2W for 16-and 20-lead networks, respectively. Typical 16-lead 01 schematic network, $0.55 (5000). Delivery, eight to 10 weeks ARO.

Dale Electronics Inc, 1122 23rd St, Columbus, NE 68601. Phone (915) 592-3253. **Circle No. 365**

VXIbus Backplane

- *Designed for press-fit connectors*
- *Utilizes 12-layer stripline construction*

Measuring 13 slot × 9U high, this VXIbus D-size backplane is designed for use with 96-pin press-fit connectors. It features a 100-MHz clock and synchronized signal line. Four parallel ECL trigger lines provide intermodule triggering at rates in excess of 10 MHz, and ECL star lines offer precision timing with a timing skew between modules of 2 nsec max. The backplane design utilizes 12-layer stripline construction to minimize crosstalk on clock and signal lines. Four ground and four power layers maximize the power distribution system, which buses voltages of −5.2, −2, 5, ±12, and ±24V. The unit has 24

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DOTRONIX

CIRCLE NO. 85

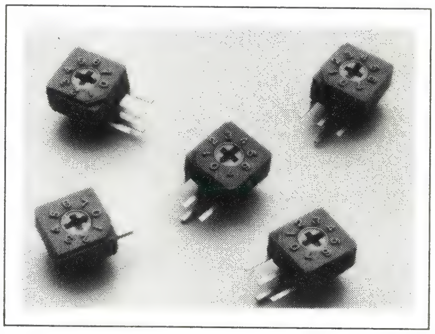
local bus lines that provide communications paths between adjacent modules. $2400.

Augat Inc, Interconnection Products Group, 33 Perry Ave, Attleboro, MA 02703. Phone (508) 222-2202. FAX 508-222-0693.

Circle No. 366

DIP-Type Rotary Switches

- *Have binary-coded output*
- *Sealed for environmental protection*



S-8000 Series sealed, DIP rotary switches are binary-coded octal devices. They are sealed with an O-ring for trouble-free soldering and washing processes. The switches employ gold-plated contacts for stable contact resistance. Contacts are rated to switch 5V at 100-mA resistive loads; the units can carry 50V at 100 mA. In addition to a 10,000-step mechanical life, the switches can withstand 50g mechanical shocks for 11 msec and vibration of 10g at 10 to 500 Hz. The units are available in top- or side-adjust styles and with real or complementary code format. Pin configurations are compatible with conventional rocker or piano-key-type DIP devices. $1.59 (1000). Delivery, eight weeks ARO.

Mepcopal Co, 11468 Sorrento Valley Rd, San Diego, CA 92121. Phone (619) 453-0332. FAX 619-481-1123. TWX 910-337-1120.

Circle No. 367

FET Switch

- *Configured for spdt operation*
- *Features 5-nsec switching speed*

Developed for S-band radar applications, the UPG107 GaAs FET switch is configured for spdt operation. Operating bandwidth extends from dc to 3.4 GHz. Typical switching speed equals 5 nsec, and the operating range spans −65 to +125°C. The switches are available in the UPG107P chip version and in the UPG107B 8-pin hermetically sealed ceramic flatpack. UPG107P, $25; UPG107B, $40 (100).

California Eastern Laboratories Inc, 3260 Jay St, Santa Clara, CA 95054. Phone (408) 988-3500. FAX 408-988-0279. **Circle No. 368**

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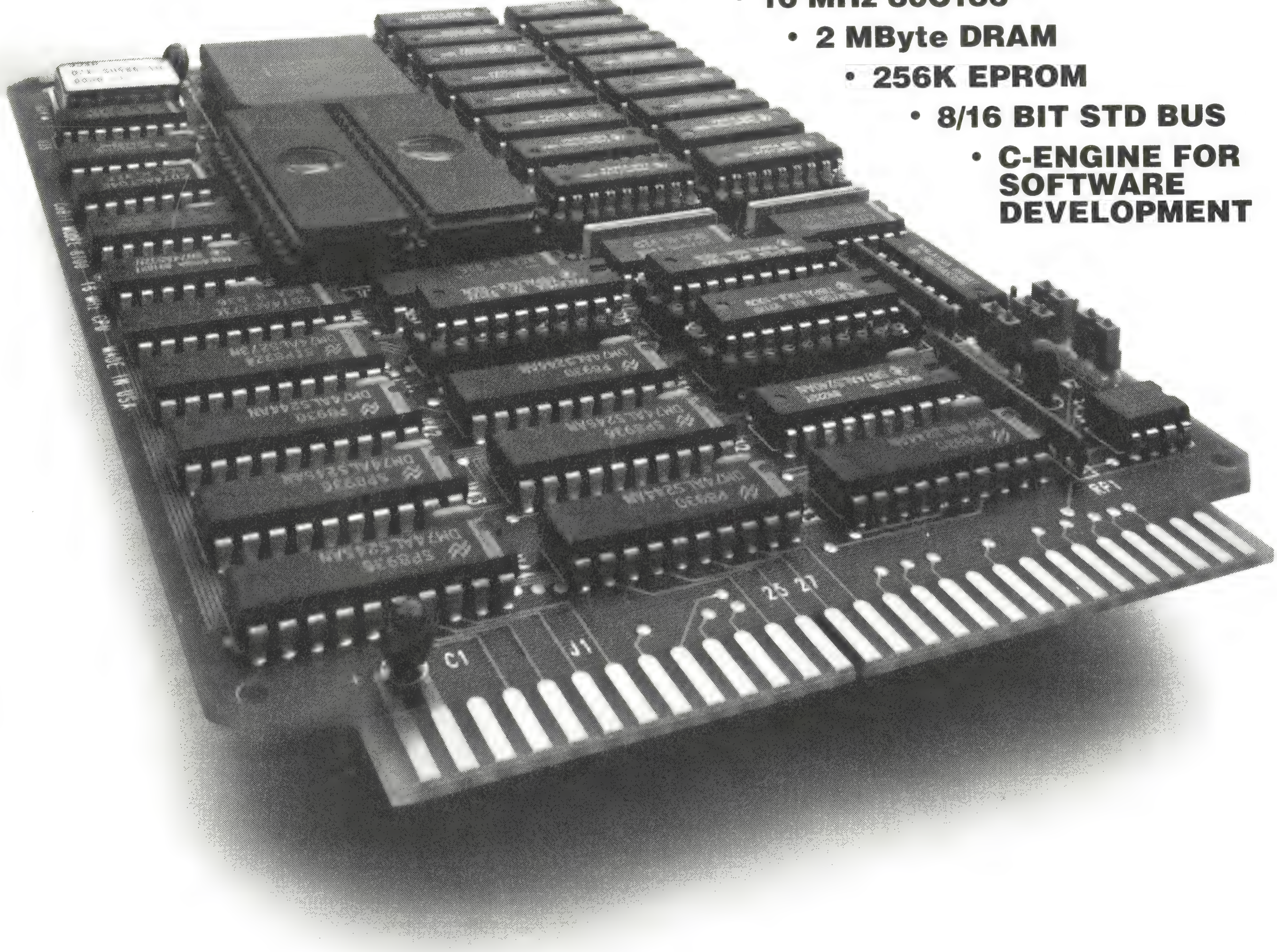
THANKS FOR THE MEMORY . . .

Cubit's New STD Bus CPU Board Includes 2 MByte of DRAM

The Model 8700 CPU Board offers an exceptional combination of processor speed and memory in the compact STD Bus format. It is compatible with over 1,000 I/O expansion boards.

Cubit's C-Engine is a complete hardware and software approach to developing code in C for the 8700. It links Borland's Turbo C Professional Package to the STD Bus CPU with a transparent interface for code development, debugging and EPROM generation.

- **16 MHz 80C186**
- **2 MByte DRAM**
- **256K EPROM**
- **8/16 BIT STD BUS**
- **C-ENGINE FOR SOFTWARE DEVELOPMENT**



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CIRCLE NO. 87

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS

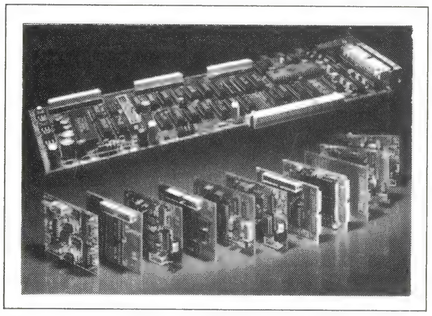
Development System For 16-MHz 80C186/188

- *Allows source-level debugging with Microsoft C*
- *Works with ANSI C compiler that produces ROMable code*

The EZ-Pro series of μP development tools now includes an in-circuit emulator that supports the 16-MHz CMOS 80C186 and 80C188. A $75 conversion utility allows source-level debugging of code compiled with Microsoft's C compiler. The vendor's own ANSI-standard C compiler costs $895 and generates machine code that you can place in ROM. A $2495 performance analyzer measures spatial activity, subroutine interactivity, and timing distribution. Emulator, from $9295; a 4k-frame trace buffer with complex triggering capabilities adds $1195.

American Automation, 2651 Dow Ave, Tustin, CA 92680. Phone (714) 731-1661. FAX 714-731-6344.

Circle No. 400



Macintosh II 16-Bit Data-Acquisition Board

- *Uses daughter boards to expand to 56 channels*
- *Takes 55k samples/sec*

The MacAdios II/16 is a NuBus board that plugs into any member of Apple's Macintosh II PC family. The unit contains a 16-bit, 15-μsec ADC with three trigger modes and three jumper-selectable gains; two 12-bit DACs; eight TTL-compatible digital inputs and outputs; and three timer/counter channels. The basic unit has eight analog input channels and makes 55k conversions/sec. Optional 16-channel daughter boards permit you to increase the number of analog inputs to 56. Other daughter boards include antialiasing filters and a 12-bit ADC that takes 833k samples/sec. The vendor supplies external panels to simplify connecting signals to the board and several menu-driven software packages that control the board's operation and process the data it acquires. $1990, including software drivers callable from C, Pascal, Basic, and Fortran.

GW Instruments Inc, 35 Medford St, Somerville, MA 02143. Phone (617) 868-4096. FAX 617-547-4096.

Circle No. 352

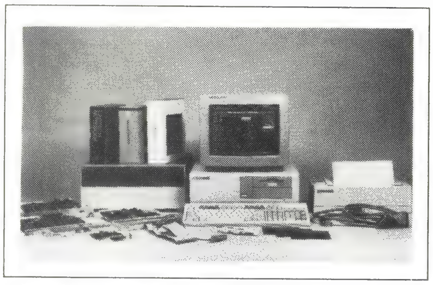
16-Bit, 100k-Sample/Sec Digitizers

- *Interface with any CPU via IEEE-488*
- *Expand to 160 channels*

The ADC488/16 and ADC488/8S resolve 16 bits and take 100k samples/sec. The 1¾-in.-high units mount outside the host computer, which can be any CPU with an IEEE-488 interface. You can configure the ADC488/16 with eight differential channels or 16 single-ended ones, and you can build systems with as many as 160 channels by using multiple units. While this digitizer has a single S/H amplifier, the 8-channel ADC488/8S includes eight S/H amplifiers for simultaneous capture of multichannel dynamic data. Both versions allow you to trigger acquisition when an analog voltage level crosses a programmable threshold. Each unit has eight digital inputs and eight digital outputs, and provides 250V of isolation between the host computer's ground and all analog and digital channels taken as a group. From $1495 for the ADC488/16 and $1995 for the ADC488/8S. For these prices, you get a buffer that holds 2k samples. For $395, you can upgrade to a 128k-sample buffer.

IOTech Inc, 25971 Cannon Rd, Cleveland, OH 44146. Phone (216) 439-4091. FAX 216-439-4093.

Circle No. 353



VXIbus-Based Data-Acquisition System

- *Includes menu-driven software*
- *Requires no programming*

The HP 75000 System 10 data-acquisition system is based on several of the vendor's previously announced VXIbus modules. The system, which is available for connection to your PC or with its own computer and printer, includes Laboratory Technologies' Labtech Notebook instrument-control software. This software performs FFT analysis and curve fitting, and it obviates programming in the traditional sense. Measurement hardware includes a 5½-digit integrating multimeter, a 16-channel thermocouple/relay multiplexer, and four 8-bit digital I/O ports. There are five empty slots in the card cage to accommodate additional measurement modules. A single cage can house more than 300 single-ended analog-input channels. $5750; PC/printer option, $4650. Delivery, four to six weeks ARO.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone (800) 752-0900.

Circle No. 354

*"WE DEPEND ON **EDN'S MAGAZINE** AND **NEWS EDITIONS** TO DELIVER THE SPECIFICS ON MAXIM PRODUCTS TO POTENTIAL CUSTOMERS."*

Mike Dikas
Director of Communications
Maxim Integrated Products

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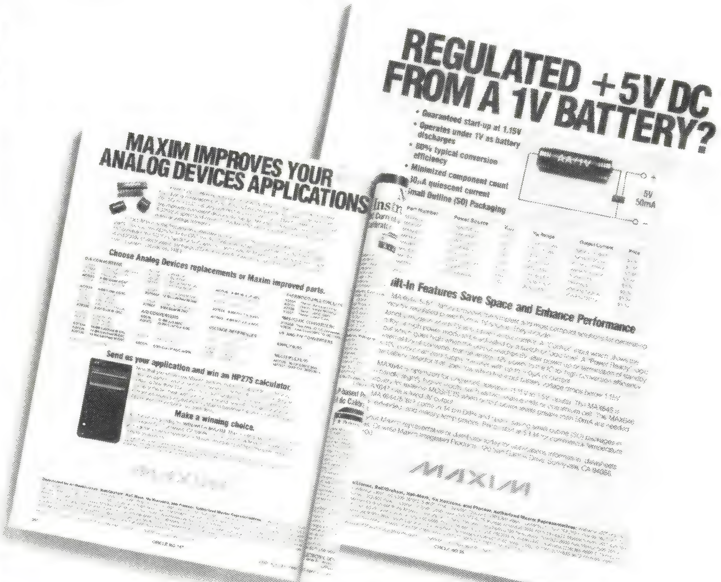
Director of Communications, Mike Dikas has piloted Maxim's advertising program since its inception. "EDN's magazine and news editions have played a significant role in introducing many of our new products. In the past two years, over 25,000 EDN Magazine and News Edition readers have responded to Maxim ads, product releases and articles," says Mike. "Our ads consistently fall in the top 10% in reader response in both editions of EDN. What's even more amazing is that we typically get less than 5% duplication of responses to the same ad in both the Magazine and News Editions."

What's that mean for Maxim? "Since both editions deliver the same circulation, it's apparent to us that the same engineers read both the Magazine and News Editions for different reasons. Given Maxim's charter of product proliferation, EDN's in-depth coverage of technical issues and timely coverage of new products are both of the utmost importance to Maxim."

Mike Dikas believes in the complementary roles of EDN Magazine and EDN News Editions.



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Zaki Corp, Maple Technology Park, 420 Maple St, Marlborough, MA 01752. Phone (508) 480-0201. FAX 508-481-0595. **Circle No. 358**

Active-Filter Design Tool

- *Lets you design a wide variety of filter types*
- *Generates simulator-compatible files for Spice*

Active Filter Design (AFD) and AFDPlus are tools for designing Butterworth, elliptic, Chebyshev, inverse-Chebyshev, and Bessel filters in any configuration. You can also design implementations of MFB (maximally flat Bessel), VCVS (voltage controlled voltage source), biquad, state-variable, and Reticon or National MF-10 switched-capacitor filters by using components of a specified tolerance; the program will then regenerate transfer functions and poles/zeros based on calculated or modified component values. The programs are menu driven and can be used by both experienced designers and beginners. You can specify filter characteristics by entering either the transfer function or the locations of poles and zeros. AFDPlus includes a compiler that can generate output files compatible with Spice, Touchstone, or Netopt simulators. AFDPlus can also read an ASCII file containing the circuit equations and use the data to design the filter. A debug mode facilitates troubleshooting when you're creating a new filter-circuit file. Both programs run on IBM PCs and compatibles. AFD, $495; AFDPlus, $850.

RLM Research, Box 3630, Boulder, CO 80307. Phone (303) 499-7566. FAX 303-449-7605. **Circle No. 359**

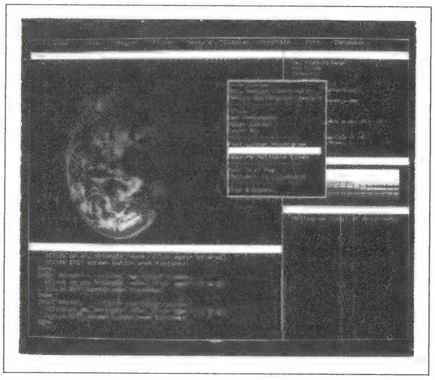

Image Manager

- *Provides menus, multiple windows, and graphical annotation*
- *Lets you access any command from the Unix shell*

The Fresco mouse-driven image-management system runs in the Unix and C environments. The graphical user interface provides pull-down and pop-up menus and multiple windows, and it lets you run the C-shell in one window. You can edit the menus or completely rearrange the user interface to meet your needs. Extensive image-processing features allow spatial filtering, point operations, multiple-image operations, and measurements such as intensity profiles and histograms. The package uses the Flex file format and utilities for convenience in handling large scientific data files. The package currently runs on Concurrent 5000 and 6000 series computers. From $4900.

Celadon Corp, 400 Fifth Ave, Waltham, MA 02154. Phone (617) 290-5775. **Circle No. 360**

ASIC Design Kits

- *Provide simulation models for gate arrays and standard cells*
- *Run on Verilog-XL logic simulator*

The Gateway/VLSI design kits provide simulation-model libraries for VLSI Technology's (San Jose, CA) VGT200 and VGT300 gate-array and VSC120 and VSC300 standard-cell products. The models are for use with Gateway's Verilog-XL logic simulator, which runs on Sun-3, Sun-4, and Apollo workstations. Each design kit includes a delay calculator that modifies the intrinsic delays of the models to account for the effects of fanout and wire capacitance; you can use the calculator for prelayout estimation of wire capacitance and for postlayout back-annotation of actual values. This feature provides a high degree of timing accuracy at each stage of design development. You can use VLSI's logic synthesizer and data-path compiler to automate the design process. These tools accept high-level descriptions of the design and then optimize for area and timing constraints. The output of the compiler is a net list that you can transfer to the Verilog-XL simulator. Each design kit, $5000.

Gateway Design Automation Corp, 2 Lowell Research Center Dr, Lowell, MA 01852. Phone (508) 458-1900. **Circle No. 361**

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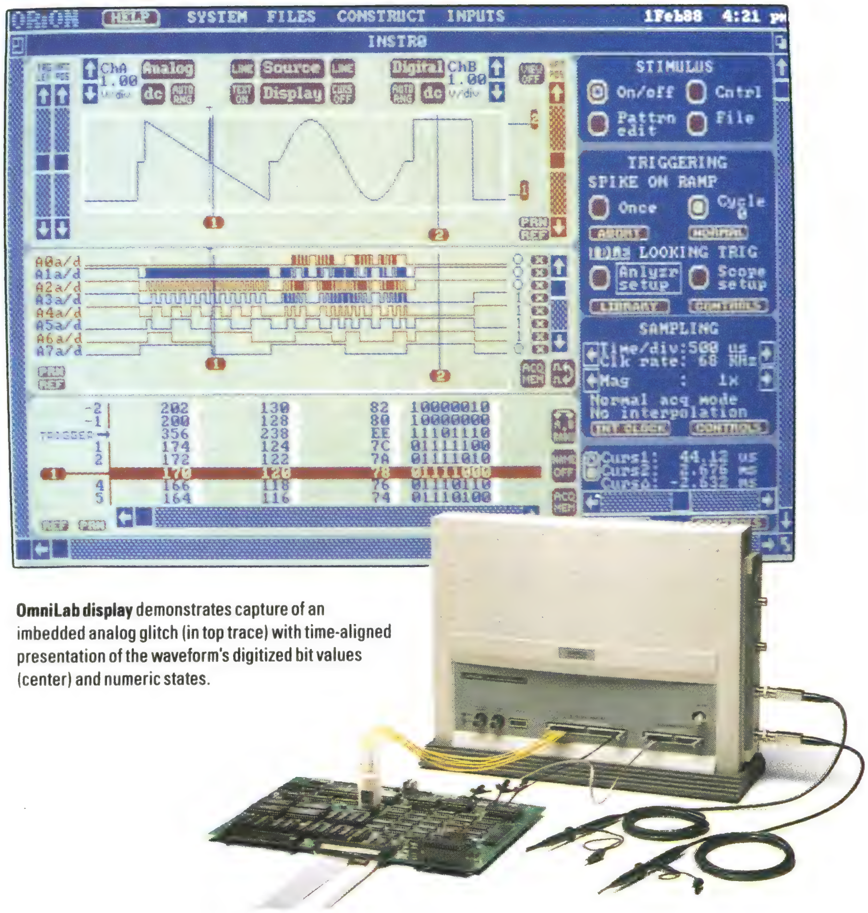

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Bandwidth:	100 MHz
Single-Shot Digitizing:	34 S/s to 204 MS/s
Repetitive Sampling:	680 MS/s
Scale Factor:	10 mV/div to 10V/div in 1-2-5 sequence
Record Length:	4K (16K optional)

LOGIC ANALYZER	
Inputs:	48, timing and state
Asynchronous Clocking:	34 MS/s on 48 inputs; 204 MS/s on 8 inputs
Repetitive Sampling:	680 MS/s on 48 inputs
Synchronous Clocking:	0 to 34 MS/s
Acquisition Memory:	4K samples (16K optional)
Disassembly Options:	Over 33 microprocessors

ANALOG STIMULUS	
Output:	8mV to 8 V peak-to-peak, 8 bit
Cycle Length:	4 to 4K samples (16K optional)
Clocking:	34 S/s to 34 MS/s
Functions:	Record, edit and playback

DIGITAL STIMULUS	
Outputs:	24, 74F tri-state drivers
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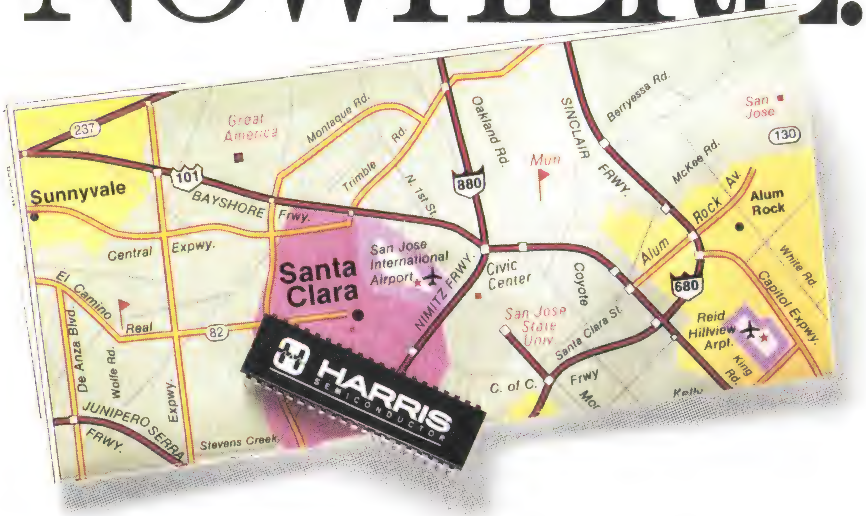

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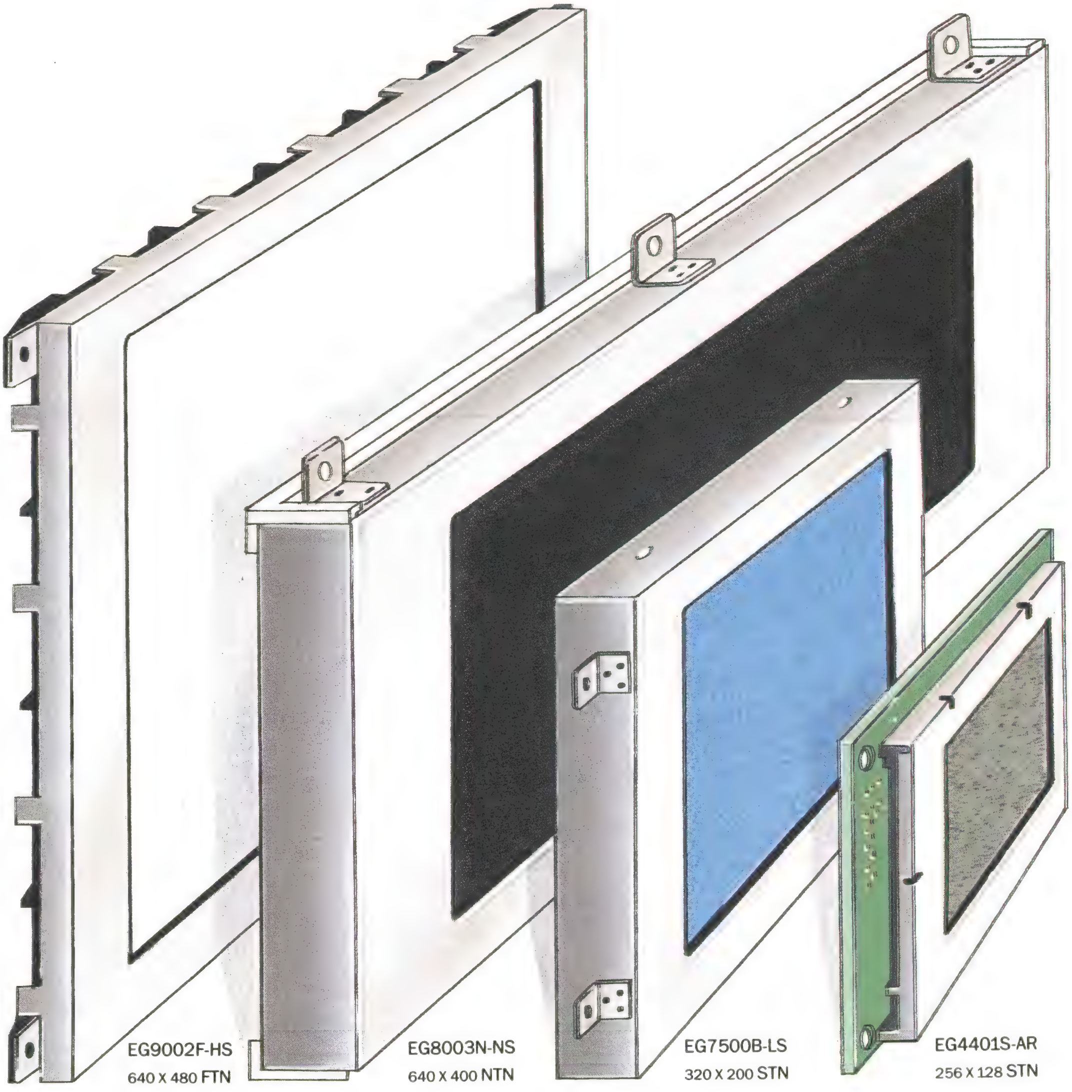

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CIRCLE NO. 91

Two publications present digital and analog products

The company's Telecommunications Device Data Book (DL136/D) contains part descriptions, electrical specifications, and diagrams, as well as packaging and pinout information, for telecommunications and Integrated Services Digital Network products. A cross-reference glossary allows you to match the company's products to competitive parts. $4.40. The Application Specific Selector Guide covers ADCs, DACs, phase-locked-loop frequency synthesizers, decoders, display drivers, smoke detectors, remote controllers, and op amps/comparators. Included in the brochure are part numbers, descriptions, and basic electrical specifications. Request SG99/D.

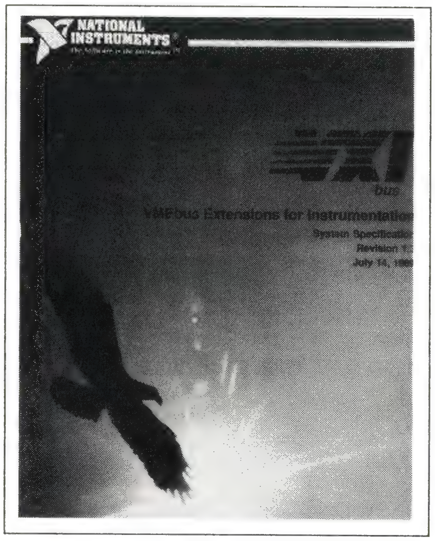
Motorola Inc, Literature Distribution Center, Box 20924, Phoenix, AZ 85036. **INQUIRE DIRECT**

Guide spotlights interface products

The vendor's 1989/1990 Technical Guide features five IEEE-488 interface products, including Sun and DEC SCSI to IEEE-488 controllers, an IEEE-488 bus analyzer, and an analog and digital I/O interface to the IEEE-488 bus and WorkBench. The publication is divided into six sections: IBM PC/AT, PS/2, and 386 products; Macintosh IEEE-488 products; Sun and DEC Workstation IEEE-488 products; serial to IEEE-488 converters and controllers; analog and digital I/O interfaces to IEEE-488 converters; and IEEE-488 bus analyzers, extenders, buffers, converters, and expanders. Each section provides specifications, software command summaries, programming examples, and block diagrams. The system solutions section shows how the company's IEEE-488 interfaces help solve the production problems that arise in the manufacture of data-acquisition and analysis systems.

IOtech Inc, 25971 Cannon Rd, Cleveland, OH 44146.

Circle No. 355



Updated version of VXIbus specification

Revision 1.3 of the VXIbus System Specification includes both major and minor changes to several areas of the Revision 1.2 Specification. In addition to the introduction, the 228-pg document contains complete and expanded information on the VXIbus implementation of VMEbus specifications, system architecture, VXIbus device implementations, command and event formats, and dynamic configuration. The appendices provide an overview of VXIbus registers, suggested backplane design, support for devices under the Revision 1.2 Specification, and a glossary. The most significant change is the removal of shared memory protocols, which will be released in a separate publication as soon as revisions are completed. Other changes encompass additional electrical and mechanical specifications, defined backplane connector-shield dimensions, differentiated intermodule separation dimensions, and message-based device operation and commands, including error-handling capability. $25.

National Instruments, 12109 Technology Blvd, Austin, TX 78727. **INQUIRE DIRECT**

Series notes logic-analysis solutions

The company's series of application notes offers solutions to complex logic-analysis measurement problems and currently covers more than 30 topics. The notes present challenges that range from finding intermittent timing problems in a digital circuit to debugging complex multiple μP or reduced-instruction-set computer-based designs. The publications demonstrate generic measurement techniques that allow you to use any logic analyzer in seeking solutions. You can make your selections from a directory of the available application notes. The Logic Analysis Newsletter and a subscription service for the Application Note Series are also available.

Gould Inc, Design & Test Systems, 19050 Pruneridge Ave, Cupertino, CA 95014. **Circle No. 356**

How to protect laser diodes

The vendor's Application Note #3, *Laser Diode Protection Strategies,* addresses the problem of protecting laser diodes against excessive power transients. The publication discusses laser-diode handling, current-source considerations, proper laser-diode connections, transient testing, and external line noise and transients.

ILX Lightwave Corp, Box 6310, Bozeman, MT 59771.

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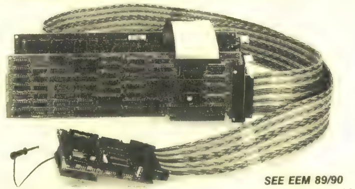

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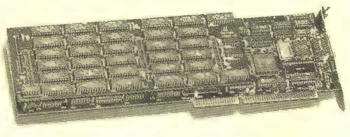

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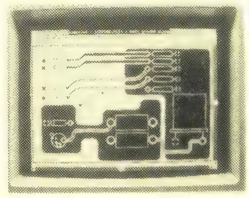

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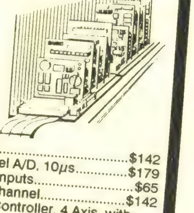

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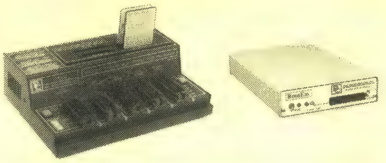

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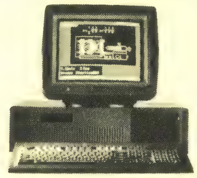

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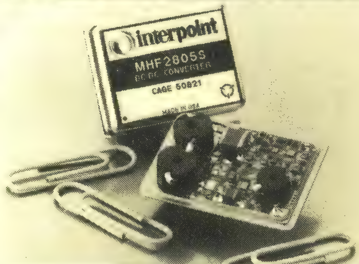

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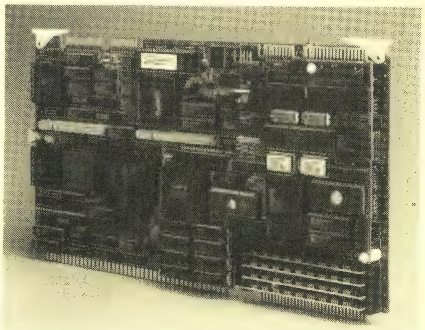

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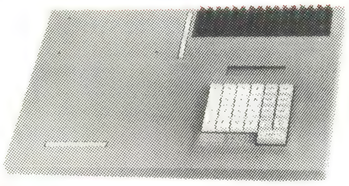

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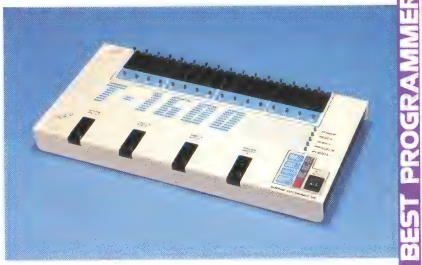

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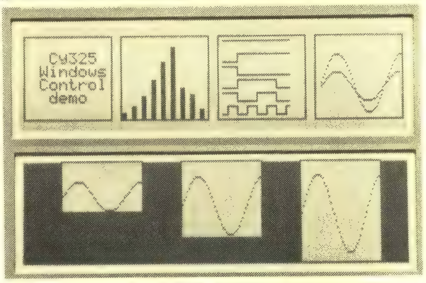

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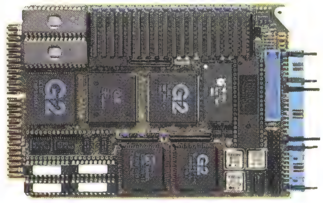

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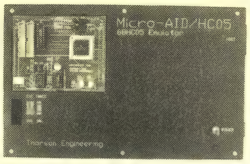

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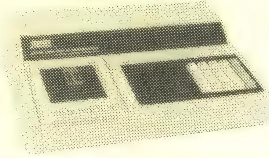

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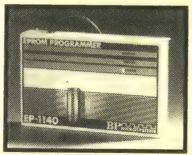

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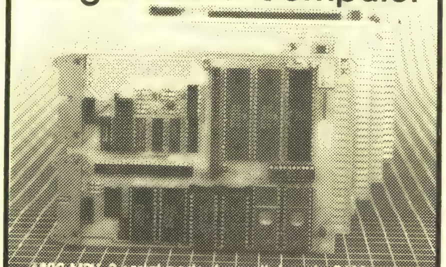

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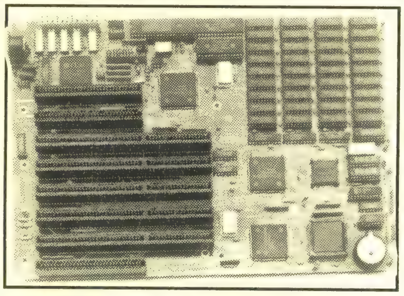

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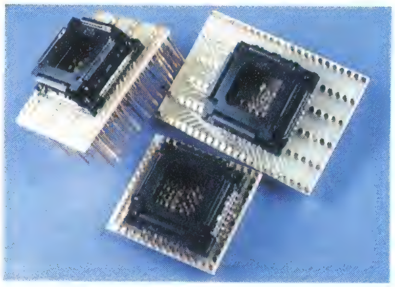

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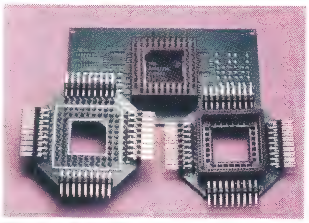

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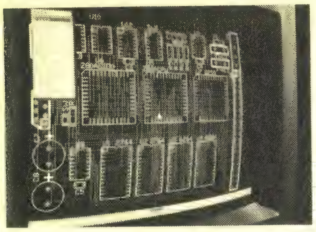

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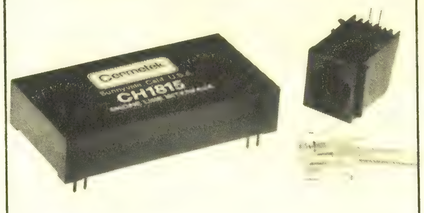

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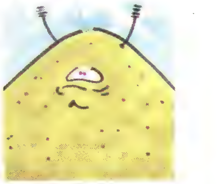

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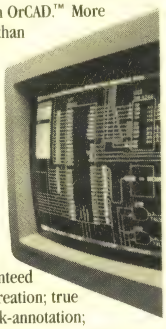

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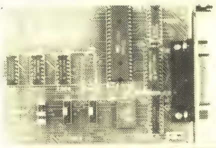

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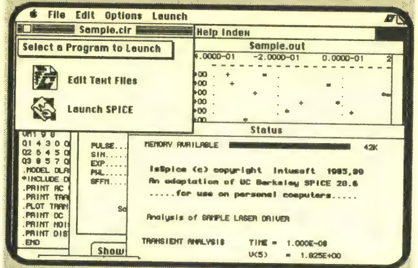

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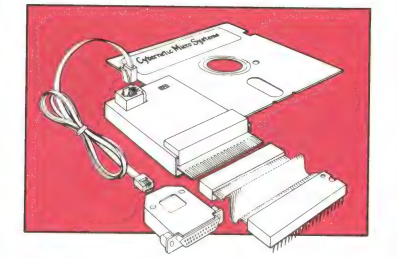

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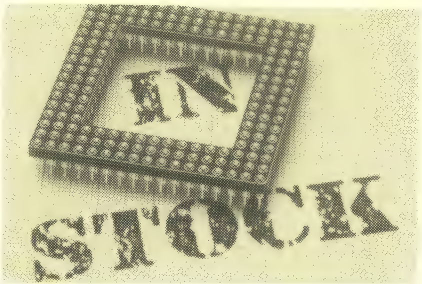

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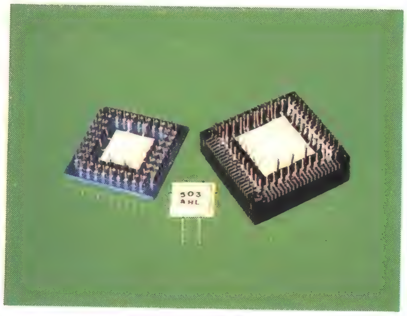

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EDN Magazine Edition
News Edition

1990 Recruitment Editorial Calendar

Issue	Issue Date	Ad Deadline	Editorial Emphasis
News Edition	Jan. 25	Jan. 4 '90	CAE/Software, Medical, Special Supplement: Engineering in the 1990s
Magazine Edition	Feb. 1	Jan. 11	Computer Boards/Microprocessors, Analog ICs, Buscon Preview, CAE Software, Power Circuits
News Edition	Feb. 8	Jan. 19	Instruments/Board Level, System Integration, Special Supplement: Embedded Systems/Microprocessors
Magazine Edition	Feb. 15	Jan. 25	Digital ICs, Computer Systems, Interconnect Technology, Sensors
News Edition	Feb. 22	Feb. 2	CAE/Hardware, Telecom, Regional Profile: No. California
Magazine Edition	Mar. 1	Feb. 8	Computer-Aided Engineering/ASICs, Computers & Peripherals, Digital ICs/Microprocessors, Semicustom ICs
News Edition	Mar. 8	Feb. 15	Analog/ICs, Automotive Electronics, Special Supplement: RISC/Microprocessors
Magazine Edition	Mar. 15	Feb. 22	Analog ICs, Components, Engineering Software, Special Design Project #1
News Edition	Mar. 22	Mar. 2	Optoelectronics, Peripherals, Regional Profile: New York, Pennsylvania & Connecticut
Magazine Edition	Mar. 29	Mar. 8	Software Special Issue—Interface ICs, Software/Programming/Microprocessors/ASICs, April Fools Section, Special Design Project #2
News Edition	Apr. 5	Mar. 16	IC/Logic ICs, Distribution, Special Supplement: Distribution
Magazine Edition	Apr. 12	Mar. 22	Communications Special Issue—Communication ICs, Communication Systems, Microprocessors, Special Design Project #3
News Edition	Apr. 19	Mar. 30	ICs/Graphics Controllers/Microprocessors, Industrial Automation, Regional Profile: So. California
Magazine Edition	Apr. 26	Apr. 5	Computer Boards/Microprocessors, Power Sources, Sensors/Transducers, Special Design Project #4, Electro Show Issue
News Edition	May 3	Apr. 12	CAE/Board Layout, Education, Special Supplement: ASICs, Electro Show Issue
Magazine Edition	May 10	Apr. 19	Analogy Technology Special Issue—Analog ICs, Analog Instruments, Digital ICs/Microprocessors/ASICs, Special Design Project #5
News Edition	May 17	Apr. 27	ICs/Memory ICs, Test & Measurement, Regional Profile: Massachusetts & New Hampshire
Magazine Edition	May 24	May 3	Microprocessors, Computers & Peripherals, Semicustom ICs/ASICs, Components, Sensors & Transducers
Magazine Edition	June 7	May 17	Software, Design Tools, Microprocessor I/O Chips, µP Support Chip Directory

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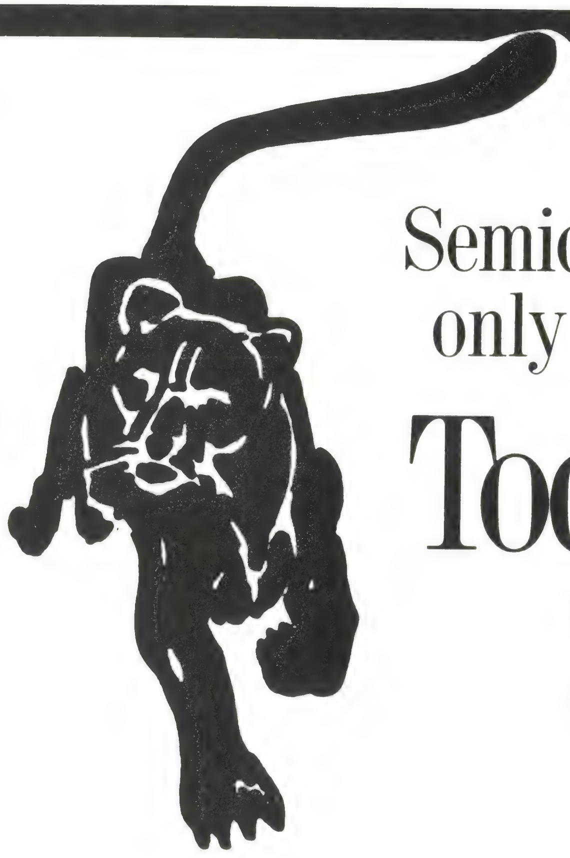

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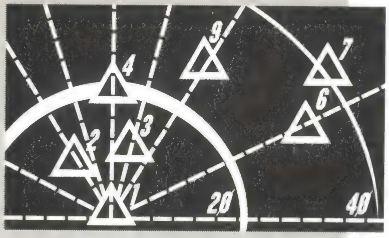

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Reason for Change

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Job Title ____________
Employer ________ From ______ To ______ City ____________
State ____________ Division ____________ Type of Industry ______
Salary ____________ Duties and Accomplishemnts: ____________

COMPENSATION/PERSONAL INFORMATION * (optional)

Years Experience | Base Salary | Commission
Bonus | Total Compensation | Asking Compensation
Min. Compensation | Date Available
☐ I own my home. How long? ______ I rent my home/apt. ☐
☐ Employed ☐ Self-Employed ☐ Unemployed
☐ Married ☐ Single | Height ______ Weight ______
Level of Security Clearance | I Will Travel
☐ U.S. Citizen ☐ Non-U.S. Citizen | ☐ Light ☐ Moderate ☐Heavy
☐ WILL RELOCATE ☐ WILL NOT RELOCATE ☐ OTHER ______
My identity may be released to: ☐ Any employer
☐ All but present employer

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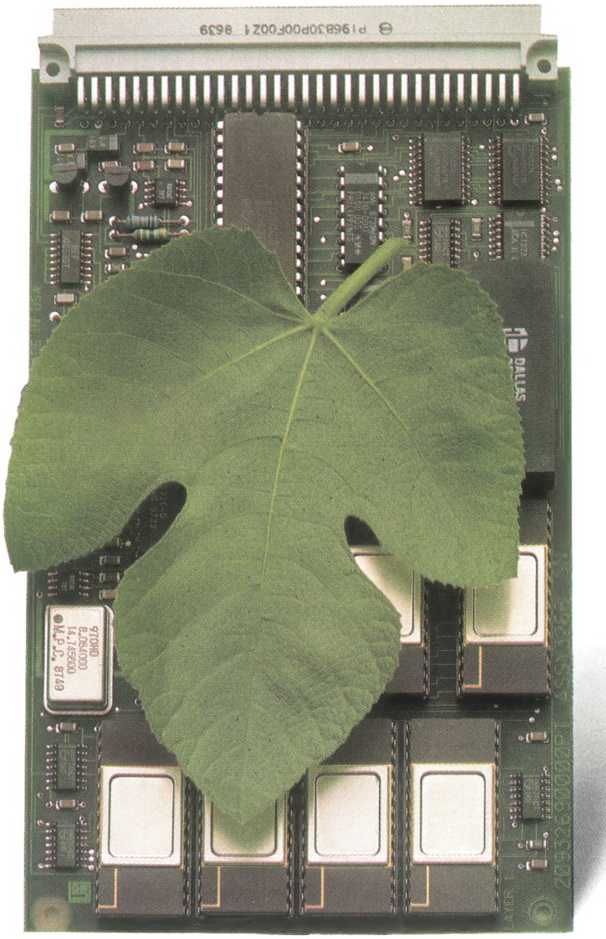

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